ENERGY ALTERNATIVES FOR BROCHET AND LAC BROCHET, MAN.

ENERGY ALTERNATIVES

FOR BROCHET AND LAC BROCHET, MAN.

Prepared for:

The communities of Brochet and Lac Brochet

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EXECUTIVE SUMMARY

1. Background

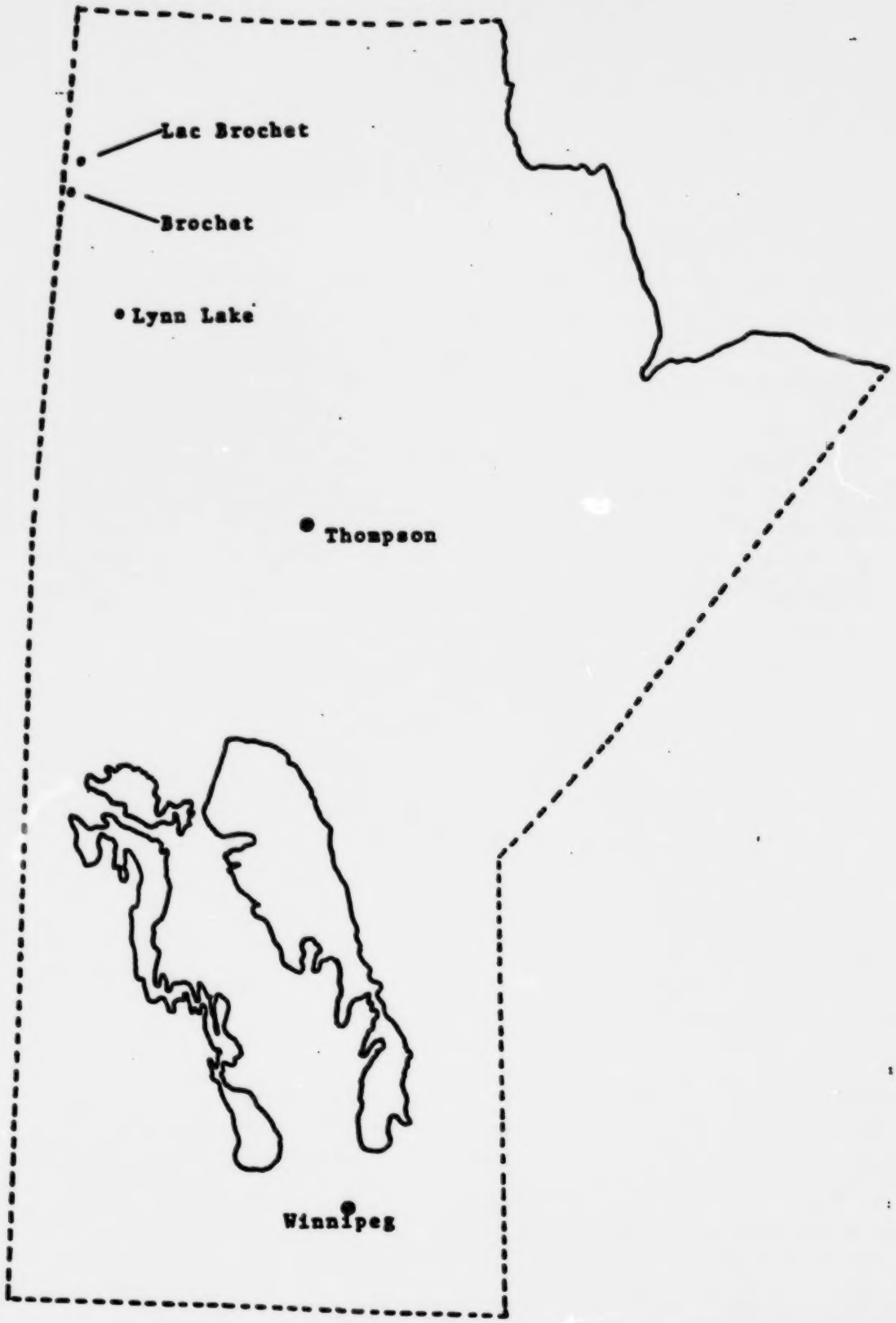
The communities of Brochet and Lac Brochet are situated in the extreme northwest region of Manitoba (see maps ES-1 and ES-2). The communities are 125 kilometers (72 miles) north of the closest Manitoba Hydro grid service system at Lynn Lake.

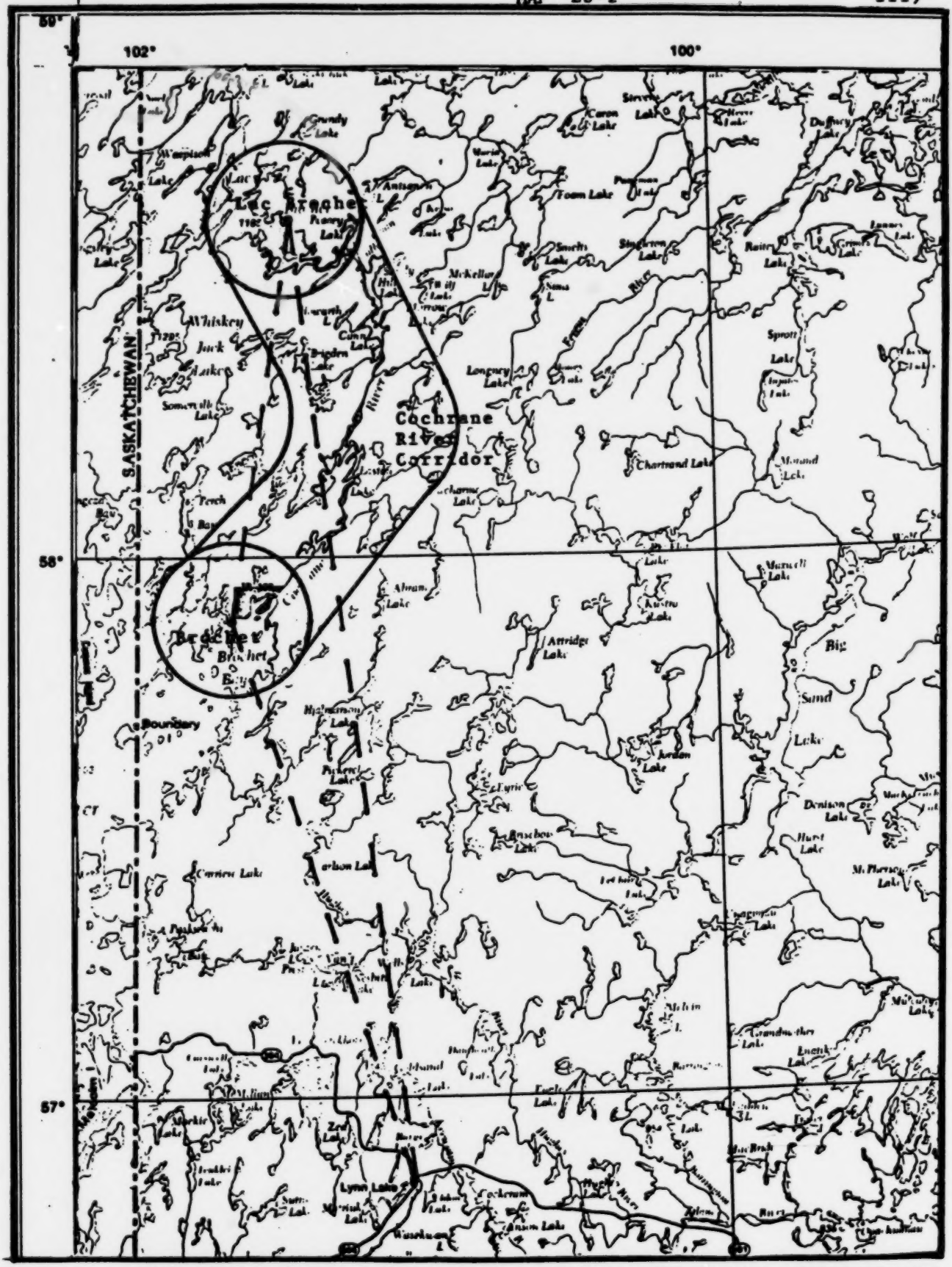
This energy alternatives study was initiated by the communities of Brochet and Lac Brochet out of concern for finite wood fuel resources and the ever increasing cost of fuel oil, gasoline and other fossil fuels. Diesel generators provide limited 15 amp. service to residential customers. The communities rely upon wood for residential heat and cooking. Diesel fuel, fuel oil and gasoline are transported to the communities via air transport or winter road.

The study area presently contains 972 individuals including Treaty Indians and Metis. These community members reside in 136 homes with an average occupancy of 5.8 - 6.0 per household. Non-Natives reside in the area as a result of professional employment opportunities. Study area economies are generally depressed with few employment opportunities available. Present economics are predominantly traditional including hunting, fishing, trapping and firewood gathering.

Based on the extrapolation of past growth trends, the study area population may triple to 2,590 individuals over the next 25 years. Housing stock may increase to 416 units as per current housing allocations. This increased population would require enhanced social support, community and economic development.

Map ES-1





GEOGRAPHIC LOCATION: BROCHET-LAC BROCHET

2. Present Energy Supply

Available data from current energy suppliers was examined to determine present energy consumption and costs. A survey of local community members was also undertaken to expand the data base. Present energy consumption has been estimated as follows:

Present Energy Consumption	1982/83
Brochet:	
Diesel (kw/mWh)	210/886
Oil (L)	303,464
Wood (cords)	1,009
Gasoline (L)	65,156
Propane (kg)	2,190
Lac Brochet:	
Diesel (kw/kWh)	66/284
Oil (L)	76,930
Wood (cords)	535
Gasoline (L)	43,245

Present energy costs experienced in the study area are estimated as per the following table ES-1.

The costs of diesel operations, oil, gasoline and propane consumption were obtained directly from suppliers. Cord wood utilization, along with the gasoline required to power the machines (boats and skidoos) used to obtain the wood, was estimated in view of survey responses and local conditions.

TOTAL ENERGY COSTS (1982/83) BOTH COMMUNITIES

Table ES-1

	Electricity 82/83 ($)	Gasoline/ Wood 82/83 ($)	Oil 82/83 ($)	Propane 82/83 ($)	Total Estimated Cost ($)
Brochet					
Treaty	$ 28,800	$ 61,950	$ 2,378	$-0-	$ 93,128
Metis	13,100	25,800	-0-	-0-	38,900
Non-Native	147,140	-0-	135,646	$2,434	285,220
Lac Brochet					
Treaty	11,180	89,100	32,500	3,900	136,680
Non-Native	143,655	-0-	19,468	3,546	166,669
TOTALS	$343,875	$176,850	$189,992	$9,880	$720,597

Average cost per KWh for each source in 82/83 was:

Electricity 25.7¢/kWh equivalent (B) 57¢/kWh (LB) Full Cost Diesel

Firewood 3.5¢/kWh equivalent ($115/cord @ 65% efficiency)

Oil 7.2¢/kWh equivalent (42.3¢/L - 83¢/L @ 60% efficiency)

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Trees in the study area are predominatly Black Spruce and are being utilized for residential heating and cooking. Due to unfavourable growing conditions, trees are usually smaller and require 200 years rotation age (maturity). Fires have burned roughly half of the land area. The annual rate of burn over the past 33 years has averaged 1.5%, amounting to 46 km^2 (18 square miles) or roughly half a township per year.

Wood consumption per home is difficult to estimate and a range of 11 - 18 cords per annum has been discussed in this report. At 18 cords per annum, approximately 100,500 cords of fuel wood will be harvested over the next 25 years. Present fuel wood reserves have been estimated at 859,300 cords.

There appears to be no imminent threat of wood resource depletion. However, access distance will increase over the planning period while additional fires may severely reduce available resources.

3. Energy Conservation Potential

Significant energy conservation potential exists in the study area. Field investigation has yielded the following cost saving estimates:

Summary of Energy Conservation Potential ($1984)

	Projected Savings ($/Year)	Estimated Cost ($)	Simple Payback (years)
Air Leakage Reduction	$79,600	$125,000	1.6
Insulation	3,500	9,000	2.6
Lighting Conversion	7,000	6,000	.85
Temperature Setback	6,000	1,000	.17
Oil Furnace Efficiency	20,000	12,000	.6
Total	$98,100	$153,000	

Air leakage reduction includes weatherstripping of doors/windows and caulking of all cracks in exterior walls of all houses and buildings in the study area, excluding the school and teacherages in Brochet.

Insulation is required along the basement walls of the church and priest's house in Brochet.

Lighting conversion includes replacing all regular fluorescent lamps and ballasts with low wattage types for classrooms in Lac Brochet and the nursing stations, grocery stores, etc. in both communities.

Temperature setback involves replacing existing thermostats with setback types for classrooms in Lac Brochet.

Oil furnace efficiency improvement includes the installation of flame retention head burners, reducing nozzle size and adjusting for thermostat settings for schools and nursing stations in both communities.

4. Energy Demand Forecasts

Three electrical load alternatives were considered in this analysis:

1) Low Load Forecast - the present 15 A, 240 V service capacity limitation for residential is maintained.

2) Intermediate Load Forecast - the residential sector installs 100 or 125 A breakers, uses new and larger appliances but electric heat is not allowed.

3) High Load Forecast - present services install 125 A or larger breakers and services upgraded to handle electric heating.

Future energy requirements were then projected in view of estimated population growth and related service requirements. Table ES-2 summarizes these future requirements in terms of the three (3) electrical load alternatives identified above.

Continued low load electrical supply will necessitate the utilization of oil for institutional heating, wood for residential heating/cooking, gasoline for wood procurement and general transportation and propane for some institutional cooking applications. These comprehensive energy requirements were projected for 25 years so as to accommodate the needs of anticipated future population levels.

Intermediate load electrical supply will enable the communities to utilize larger electrical appliances, power motors, etc. as is the common practise for grid-connected communities. However,

Projected Energy Requirements
Brochet & Lac Brochet

Table ES-2

	Present 1982/83	1988	1993	1998	2003	2008
Low Load						
Brochet:						
Diesel (kw/mWh)	210/886	246/1040	271/1159	406/1716	446/1899	496/2125
Oil (l)	303,464	303,464	303,464	436,800	436,800	436,800
Wood (Cords)	1,001	1,386	1,661	1,991	2,431	2,970
Gasoline (l)	65,156	90,216	108,116	129,596	158,236	193,320
Propane (kg)	2,190	2,190	2,190	4,630	4,630	4,630
Lac Brochet:						
Diesel (kw/mWh)	66/270	129/512	149/599	196/803	221/931	248/1059
Oil (l)	76,910	122,120	124,120	190,000	192,000	194,000
Wood (Cords)	495	770	990	1,210	1,485	1,760
Gasoline (l)	43,245	67,270	86,490	105,710	129,735	153,760
Intermediate Load						
Brochet (kw/mWh)	210/886	585/2143	816/2721	1097/3757	1265/4307	1475/5000
Oil/Wood/Gasoline same as Low Load - Propane not required						
Lac Brochet (kw/mWh)	66/270	302/985	447/1559	612/2016	747/2946	852/2793
Oil/Wood/Gasoline same as Low Load - Propane not required						
High Load						
Brochet (kw/mWh)	210/886	1421/4815	1765/5759	2554/8566	2901/9436	3337/11172
Wood (cords 20% Low Load)	200	277	332	398	486	594
Gas (L - 20% Low Load)	13,030	18,045	21,623	25,920	31,467	38,664
Oil/Propane not required						
Lac Brochet (kw/mWh)	66/270	766/2471	1144/3651	1451/3651	1768/5631	1991/6368
Wood (cords 20% Low Load)	99	154	198	242	297	352
Gas (L - 20% Low Load)	8,649	13,454	17,298	21,142	25,947	30,752
Oil/Propane not required						

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intermediate electrical load service will not significantly displace other (wood, oil, gasoline) energy sources which are utilized primarily for heating purposes. Propane would no longer be required as electricity will be utilized for major appliances, water heating, etc.

High load electrical supply will enable the communities to utilize electricity for all major applications including heat. Approximately 20% of low load wood/gasoline projections are included in high load assumptions to account for individuals who would not convert to electric heat as well as the continued utilization of wood/gasoline as a back-up heating system.

5. Cost Considerations

Three (3) electrical energy supply alternatives were analyzed in order to satisfy the aforementioned load forecasts. The alternative electrical supply developments include: continued diesel operation, small hdyro electric development and transmission tie-in to the Manitoba Hydro grid at Lynn Lake.

Diesel unit additions were based upon growth estimates and discussions with Manitoba Hydro. Initial estimates of $500/kw installed were increased by 8% per annum in order to reflect inflation.

Brochet:	New Diesels Installed (kw)	Inflated Installed Cost ($)
Year: 1987	350	$ 323,000
1994	300	350,000
2002	600	1,296,000
2009	300	1,110,000
Lac Brochet:		
Year: 2004	525	1,320,000

Diesel operating and maintenance (o/m) charges were based upon actual Manitoba Hydro data and were increased according to load requirements and inflation assumptions.

Several potential sites have been located on the river between Lac Brochet and Brochet, and compared for a range of possible hydroelectric development sizes. While study has indicated that the river flow is suitable for hydroelectric development, the

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sites for development are of limited head, which results in a relatively costly plant and equipment. The most economical site for capacities up to about 3,000 kw has been identified at the rapids about 14 km northeast of Brochet. For capacities greater than about 3,500 kw, the most economical scheme has been determined to be the diversion of a portion of the Cochrane River flow through Engen Lake to a dam and powerhouse located near an arm of Birch Bay.

Capital costs for potential hydroelectric development have been estimated as follows:

Hydroelectric Development
Capital Cost Estimates ($-1984 - 000's)

	Single Site Brochet and Lac Brochet	Brochet Alone	Lac Brochet Alone
Low Load	$13,500	$ 7,900	$ 8,800
Intermediate Load	18,200	11,500	10,400
High Load	27,800	n/a	n/a

These capital costs estimated include all labour, materials, transportation, storage and interest costs assuming a three (3) year construction period.

Operation and maintenance costs for hydroelectric alternatives were estimated at 1.7% of capital cost and include the cost of energy. Operating and maintenance costs were then projected to account for inflation and development expansion.

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Transmission line tie-in with the Manitoba Hydro grid system at Lynn Lake is a plausible alternative. Capital costs for transmission line tie-in including labour, materials, transportation and interest during construction have been estimated as follows:

Transmission Tie-In
Capital Cost Estimates ($-1984 - 000's)

Lynn Lake-Brochet	$ 7,680
Brochet-Lac Brochet	5,460
Total	$13,140

Capital cost estimates for transmission tie-in have been verified with Manitoba Hydro.

Operation and maintenance costs for transmission tie-in have been estimated at 1.2% of capital cost. The additional cost of energy provided by the grid connection at Lynn Lake has been initially identified by Manitoba Hydro at 1.74¢/kWh. Operation and maintenance energy charges were projected in order to account for load growth and inflation.

6. Financial Analysis

The various energy alternatives were analyzed by examining the total energy requirements of the two communities including electricity, oil, wood/gasoline and propane as discussed. All capital, operation/maintenance, and energy costs were projected forward on the basis of determined load projections assuming a rate of inflation of 8%. The capital cost of the various alternatives was amoritized over the useful economic life of the various developments. These flows were discounted at 12% thereby resulting in an effective discount factor of 4%.

The present value analysis applied to the various alternatives is presented in Table ES-3.

Of all the alternatives considered, transmission line tie-in under high load energy assumptions is the most economical alternative for the communities. High load (electric heat) will enable the study communities to virtually eliminate costly heating oil and wood/gasoline consumption at an overall cost which is much cheaper than the present energy system or a hydroelectric development. Transmission line (from Lynn Lake) construction costs are the most economical of any of the enhanced electrical energy alternatives and therefore contribute significantly to the overall energy cost reduction.

Hydroelectric alternatives comprise the greatest capital cost of any of the enhanced electrical energy alternatives. Hydroelectric development also entails the most economical operation and maintenance energy costs of the enhanced electrical supply alternatives. It is therefore observed that the high capital cost of hydroelectric development places this alternative in the

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highest overall cost category of enhanced energy alternatives.

Diesel generation is the most costly of all the energy alternatives considered. While diesel generation comprises the least capital cost, limited diesel generated electricity and associated wood/gas/oil requirements also comprise the highest operation/maintenance and energy costs which enable reduced 15 amp. diesel generation to be compared to the other alternatives from a cost effectiveness viewpoint. Limited 15 amp. diesel service with related wood/gas/oil requirements will cost the study communities approximately $155 k ($-1984) per year more, for the next 25 years, than installing a transmission line from Lynn Lake and providing electric heat.

All other variations concerning separate developments or tie-ins are more costly than the transmission tie-in for Brochet/Lac Brochet discussed above.

7. Community Concerns

Present rate conditions are such that electric heat conversion, assuming grid tie-in, would cost residents only $5 - $10 per month more than is presently paid for limited 15 amp. service and the cost of wood procurement. The local survey indicated that 90% of study area residents would convert to electric heat if costs would be similar to average monthly charges presently incurred in obtaining wood resources. In view of the above, transmission line electric heat would not only be desireable but also economically acceptable to study area residents.

Environment impacts of either intermediate load hydroelectric or transmission line connection would not be too significant. Concern would rest with a slight elevation in river level, minimal flooding, aesthetics of road/transmission access and possible effects upon caribou migration. Specific study would be required prior to development.

Present Value Energy Costs (1984 dollars)
Brochet and Lac Brochet
Inflation 8%, P.V. Discount 12%
Projection Period 1985 - 2009

Table ES-3

(000's)	Amortized Cap. Cost	O/M	Energy Cost	Total Cost
Continued Diesel - Low Load:				
Brochet (including oil, propane, wood/gas)	840	4,617	6,513	11,970
Lac Brochet (including oil, propane, wood/gas)	330	5,386	3,392	9,108
Total	1,170	10,003	9,905	21,078
Hydroelectric - Intermediate:				
Brochet - Lac Brochet (including wood/gas, oil)	14,610	3,463	9,703	27,776
Brochet Only (including wood/gas, oil)	9,580	2,219	6,482	18,281
Lac Brochet Only (including wood/gas, oil)	8,443	1,955	3,221	13,619
Hydroelectric - High:				
Brochet & Lac Brochet (including wood/gas)	23,144	3,414	953	27,511
Transmission Line:				
Brochet & Lac Brochet - Intermediate (including wood/gas, oil)	11,839	1,918	10,917	24,674
Brochet & Lac Brochet - High (including wood/gas)	11,839	1,918	3,436	17,193
Brochet Only - Intermediate (including wood/gas, oil)	6,919	1,170	7,254	15,343
Brochet Only - High (including wood/gas)	6,919	1,170	2,285	10,374

ÉTUDE DES OPTIONS ÉNERGÉTIQUES
BROCHET ET LAC BROCHET (MANITOBA)

Résumé

Cette étude des options énergétiques a été exécutée à la demande des localités de Brochet et de Lac Brochet, qui s'inquiétaient du risque d'un épuisement de leurs ressources en bois combustible et de la hausse constante du coût du mazout, de l'essence et des autres combustibles fossiles. Des groupes électrogènes diesel fournissaient un service limité de 15 ampères aux consommateurs du secteur résidentiel. Les citoyens de ces deux localités doivent compter sur le bois pour chauffer leurs maisons et cuire leurs aliments. Le combustible diesel, le mazout et l'essence sont transportés dans cette région par avion ou, l'hiver, par la route.

La région à l'étude renferme actuellement une population de 972 habitants, parmi lesquels on trouve des Indiens reconnus par un traité et des Métis. Ces citoyens demeurent dans 136 maisons dont le taux d'occupation moyen se situe entre 5,8 et 6 par ménage. Les non-autochtones se sont installés dans cette région pour des raisons d'emploi. L'économie de la région est généralement peu florissante, les possibilités d'emploi y étant rares. Elle est actuellement dominée par des occupations traditionnelles, comme la chasse, la pêche, le piégeage et la cueillette du bois de chauffage.

Si les taux de croissance observés jusqu'à maintenant se maintiennent, la population de la région triplera presque au cours des 25 prochaines années, pour atteindre 2 590 habitants. Le parc domiciliaire augmentera à 416 unités, selon les taux d'occupation actuels. Pour satisfaire les besoins de cette population accrue, il faudra améliorer l'infrastructure sociale et intensifier le développement économique.

On a analysé les diverses options énergétiques en examinant l'ensemble des besoins en énergie des deux localités y compris l'électricité, le mazout, le bois/l'essence et le propane. Tous les coûts d'équipement, d'exploitation et d'entretien et d'énergie ont été projetés selon les charges retenues, en supposant un taux d'inflation de 8 %. Le coût d'équipement des diverses options a été amorti sur la durée de vie économique des installations. Ces mouvements d'argent ont été escomptés à 12 %, ce qui donne un facteur d'actualisation réel (inflation déduite) de 4 %.

Le tableau qui suit donne l'analyse de la valeur actualisée appliquée à chacune des options envisagées.

De toutes les options retenues, le rattachement des lignes de transport au réseau dans une hypothèse de charge élevée, s'avère la solution la plus économique pour les localités en cause. Il leur en coûterait environ 3,9 millions de dollars ou 155 000 $ (1984) par année de plus, au cours des 25 prochaines années, pour continuer à s'alimenter au moyen des groupes électrogènes diesel de 15 ampères avec appoint de mazout, de bois/d'essence et de propane.

Toutes les autres variantes (aménagements hydroélectriques ou rattachements) s'avèrent plus coûteuses que la connexion des lignes de transport de Brochet/Lac Brochet.

Les coûts actuels de l'énergie, dans la région à l'étude, sont de l'ordre suivant:

Coût Total De l'Énergie (1982-1983) Dans Les Deux Localités

	Électricité 82/83 ($)	Essence/ bois 82/83 ($)	Mazout 82/83 ($)	Propane 82/83 ($)	Coût total estimatif ($)
Brochet					
Indiens reconnus par traité	628 000 $	61 950 $	2 378 $	-	93 128 $
Métis	13 100	25 800	-	-	38 900
Non-autochtones	147 140	-	135 646	2 434	285 220
Lac Brochet					
Indiens reconnus par traité	11 180	89 100	32 500	3 900	136 680
Non-autochtones	143 655	-	19 468	3 546	166 669
TOTAL	343 875 $	176 850 $	189 992 $	9 880 $	720 597 $

Le coût moyen par kWh de chaque source d'énergie en 1982-1983 s'établissait comme suit:

Électricité 25,7 ¢/kWh (LB) en 1982-83 Diesel au plein prix

Bois de Chauffage 3,5 ¢/kWh (115 $/corde pour un rendement de 65 %)

Mazout 7,2 ¢/kWh (42,3 ¢/l - 83¢/l pour un rendement de 60 %)

Il existe des possibilités d'économies d'énergie appréciables dans les deux localités. Les études sur le terrain ont permis de calculer les économies de coût suivantes:

Sommaire Des Possibilités D'Économies d'Énergie

	Économies projetées (en $/an)	Coût estimatif (en $)	Recouvrement simple (en années)
Réduction des fuites d'air	79 600	125 000	1,6
Isolation	3 500	9 000	2,6
Conversion de l'éclairage	7 000	6 000	,85
Abaissement du thermostat	6 000	1 000	,17
Rendement du calorifère au mazout	20 000	12 000	,6
TOTAL	98 100	153 000	

En ce qui concerne la charge d'électricité, trois possibilités ont été retenues dans cette analyse:

- Faible charge - service résidentiel de 15 A (diesel) actuel;
- Charge intermédiaire - service résidentiel de 100 A, sans chauffage électrique;
- Charge élevée - service résidentiel de 100 A, avec chauffage électrique.

Le tableau suivant présente une estimation des besoins énergétiques de l'ensemble de la collectivité, pour chacune des trois charges retenues.

Dans la région à l'étude, la forêt est dominée par l'épinette noire, que l'on utilise pour le chauffage résidentiel et la cuisson. Comme ils poussent dans des conditions peu favorables, les arbres sont habituellement plus petits et atteignent leur dimension d'exploitabilité au bout de 200 ans. Les incendies de forêt ont ravagé la moitié des terres boisées. Le taux annuel de consommation depuis 33 ans s'établit en moyenne à 1,5 % ce qui équivaut à 46 km^2 (18 milles carrés) soit environ la moitié d'un township par année.

La consommation de bois par ménate est difficile à estimer, et les auteurs du rapport ont considéré un éventail de consommations possibles de 11 à 18 cordes par année. Au rythme de 18 cordes par année, environ 100 500 cordes de bois de chauffage seront récoltées au cours des 25 prochaines années. Les réserves actuelles ont été estimées à 850 cordes.

Il ne semble pas y avoir pour l'instant un risque d'épuisement des ressources en bois. Cependant, la distance des ressources au point d'utilisation augmentera au cours de la période de la projection, et d'autres incendies de forêt pourraient réduire considérablement les ressources disponibles.

Une étude préliminaire a révélé qu'au moins deux sites possibles sur la rivière Cochrane pourraient être aménagés en centrales hydroélectriques. Le coût d'équipement d'une centrale hydroélectrique a été estimé comme suit:

Centrale hydroélectrique
Estimation du coût d'équipement en milliers de $ de 1984

	Site unique Brochet et Lac Brochet	Brochet seulement	Lac Brochet seulement
Faible charge	13 500 $	7 900 $	8 800 $
Charge intermédiaire	18 200	11 500	10 400
Charge élevée	27 800	S/O	S/O

Un rattachement des lignes de transport au réseau de la Manitoba Hydro à Lynn Lake est une solution plausible. Le coût d'équipement d'une interconnexion est estimé comme suit:

Connexion des lignes de transport au réseau
Estimation du coût d'équipement en milliers de $ de 1984

Lynn Lake-Brochet - 7 680 $ Brochet-Lac Brochet - 5 460 $
TOTAL Lynn Lake-Lake Brochet - 13 140 $

Les coûts d'exploitation et d'entretien d'une centrale hydroélectrique sont estimés à 1,7 % du coût d'équipement et comprennent le coût de l'énergie. Les coûts d'exploitation et d'entretien de l'interconnexion équivaudraient à 1,2 % du coût d'équipement. Le coût supplémentaire de l'énergie apportée par le rattachement au réseau à Lynn Lake est présenté, dans cette analyse, comme un élément de coût distinct.

La construction d'une centrale hydroélectrique de charge intermédiaire où la connexion des lignes de transport n'aurait pas d'effets indus sur l'environnement. Les facteurs à considérer sont le risque d'une légère élévation du niveau de la rivière et d'une inondation minimale, l'apparence des routes et des couloirs de transport et les effets possibles des travaux de construction sur la migration du caribou.

L'étude a été réalisée par P.M. Associates Ltd., Acres Consulting Services Limited et The Conserver Group Inc. pour les collectivités de Brochet et Lac Brochet (Man.) à l'aide d'une subvention des Affaires indiennes et du Nord Canada et du Programme de démonstration dans les collectivités éloignées d'Énergie, Mines et Ressources Canada.

Besoins Énergétiques Projetés - Brochet et Lac Brochet

	Présent 1982/1983	1988	1993	1998	2003	2008
Faible charge						
Brochet:						
Diesel (kW/MWh)	210/886	246/1040	271/1159	406/1716	446/1899	496/2125
Mazout (l)	303 464	303 464	303 464	436 800	436 800	436 800
Bois (cordes)	1 001	1 386	1 661	1 991	2 431	2 970
Essence (l)	65 156	90 216	108 116	129 596	158 236	193 320
Propane (kg)	2 190	2 190	2 190	4 630	4 630	4 630
Lac Brochet:						
Diesel (kW/MWh)	66/270	129/512	149/599	196/803	221/931	248/1059
Mazout (l)	76 910	122 120	124 120	190 000	192 000	194 000
Bois (cordes)	495	770	990	1 210	1 485	1 760
Essence (l)	43 245	67 270	86 490	105 710	129 735	153 760
Charge intermédiaire						
Brochet (kW/MWh)	210/886	585/2143	816/2721	1097/3757	1265/4307	1475/5000
Mazout/Bois/Essence comme dans "Faible charge" - Propane non requis						
Lac Brochet (kW/MWh)	66/270	302/985	447/1559	612/2016	747/2946	852/2793
Mazout/Bois/Essence comme dans "Faible charge" - Propane non requis						
Charge élevée						
Brochet (kW/MWh)	210/886	1421/4815	1765/5759	2554/8566	2901/9436	3337/11172
Bois (cordes - 20 % de "Faible charge")	200	277	332	398	486	594
Essence (l - 20 % de "Faible charge")	13 030	18 045	21 623	25 920	31 467	28 664
Mazout/Propane non requis						
Lac Brochet (kW/MWh)	66/270	766/2741	1144/3651	1451/3651	1768/5631	1991/6368
Bois (cordes - 20 % de "Faible charge")	99	154	198	242	297	352
Essence (l - 20 % de "Faible charge")	8 649	13 454	17 298	21 142	25 947	30 752
Mazout/Propane non requis						

Valeur actualisée des coûts de l'énergie (en dollars de 1984)
Brochet et Lac Brochet
Inflation: 8 %; facteur d'actualisation: 12%
Période de projection: 1985-2009

(en milliers de dollars)	coût d'équipement amorti	Exploitation et entretien	Coût de l'énergie	Coût total
Maintien du diesel, faible charge:				
Brochet (avec mazout), propane, bois/essence)	840	4 617	6 513	11 970
Lac Brochet (avec mazout, propane, bois/essence)	330	5,386	3,392	9,108
Total	1 170	10 003	9 905	21 078
Centrale hydroélectrique, charge intermédiaire:				
Brochet - Lac Brochet (avec bois/essence, mazout)	14 610	3 463	9 703	27 776
Brochet seulement (avec bois/essence, mazout)	9 580	2 219	6 482	18 281
Lac Brochet seulement (avec bois/essence, mazout)	8 443	1 955	3 221	13 619
Centrale hydroélectrique, charge élevée:				
Brochet et Lac Brochet (avec bois/essence)	23 144	3 414	953	27 511
Ligne de transport:				
Brochet et Lac Brochet, charge intermédiaire (avec bois/essence, mazout)	11 839	1 918	10 917	24 674
Brochet et Lac Brochet, charge élevée (avec bois/essence)	11 839	1 918	3 436	17 193
Brochet seulement, charge intermédiaire (avec bois/essence, mazout)	6 919	1 170	7 254	15 343
Brochet seulement, charge élevée (avec bois/essence)	6 919	1 170	2 285	10 374

1.

INTRODUCTION AND ACKNOWLEDGEMENTS

1. INTRODUCTION AND ACKNOWLEDGEMENTS

The communities of Brochet and Lac Brochet are situated in the extreme north-west region of Manitoba (see accompanying maps,1-1 and 1-2). With a combined population of approximately 972, the two communities are some distance from the Manitoba Hydro electrical service system. Electrical energy needs are presently serviced by diesel generation while fuel oil and wood serve winter heating demand.

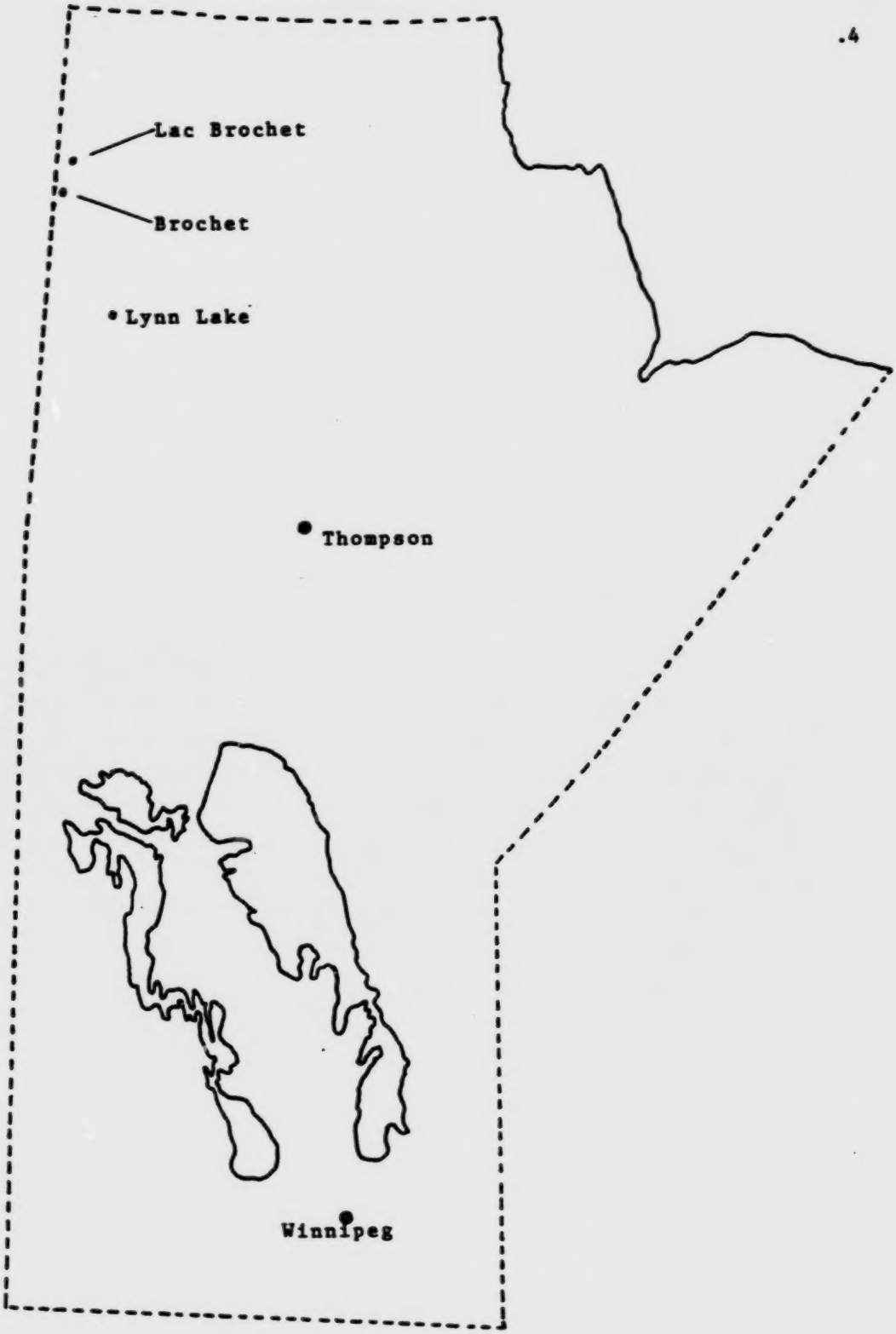
The nearby Cochrane River flows between Reindeer Lake and Lac Brochet. Between these two lakes, the river drops some 25 m in elevation and produces an average flow of some 150 m^3/s. This flow level indicates an energy potential of nearly 300 GW.h/yr. The communities of Brochet and Lac Brochet have recognized the possibility of utilizing some of this hydro electric potential to lessen their dependency on expensive fossil fuels and wood. Community representatives approached Energy, Mines and Resources Canada (EMR) and The Department of Indian Affairs and Northern Development (DIAND), and subsequently received funding assistance to conduct a study of energy requirements and future options. A study team comprised of P. M. Associates Ltd., Management, Financial & Design Consultants, Acres Consulting Services Ltd. and The Conserver Group Inc., Energy Engineers was contracted to undertake this assignment.

The following report is intended to satisfy study requirements as per the Terms of Reference approved by E.M.R., D.I.A.N.D. and the two communities. Chapters 2 and 3 provide a general description of the study area as well as community base data. Chapter 4 utilizes this base data and projects future growth patterns for the two communities. Chapter 5 translates community base data to energy requirements and goes on to describe projected growth in terms of energy load forecasts. Chapter 5 also includes existing energy conservation potential. Chapter 6 assesses existing wood fuel resources in light of anticipated community growth. Chapter 7 presents a

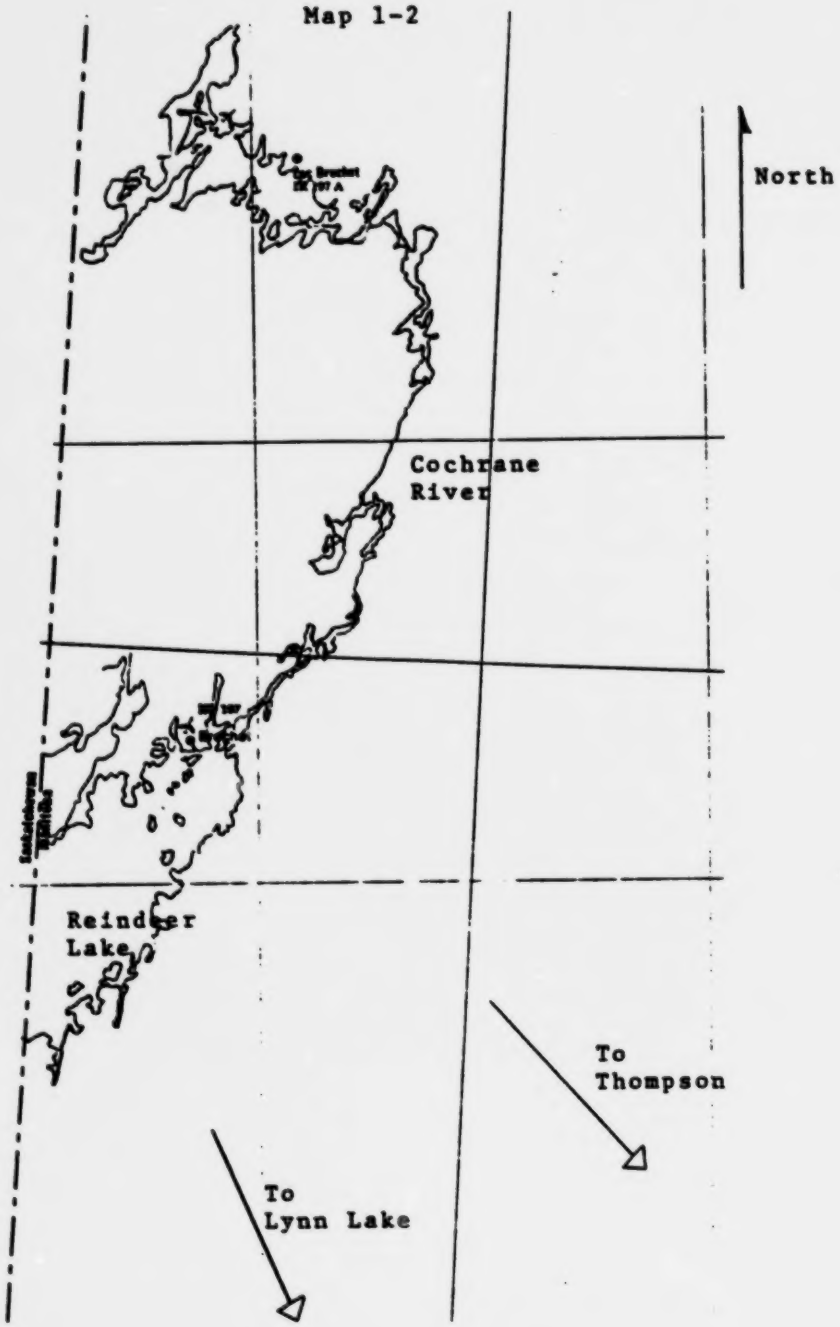
capital cost analysis of the various energy alternatives considered in this study. Chapter 8 addresses the environmental concerns associated with the energy alternatives. Chapter 9 utilizes cost data to arrive at a net present value analysis which examines the various energy alternatives over their respective life cycles. Chapter 10 proceeds to discuss the major socio-economic impacts associated with the potential energy alternatives identified. Study team members concentrated on their respective areas of expertise as follows: P.M. Associates Ltd. - community base data projections and financial analysis; Acres Consulting Services Ltd. - small hydro, transmission tie-in and environmental impact; the Conserver Group Inc. - energy useage, energy cost and conservation potential.

The study team wishes to acknowledge the participation of many whose co-operative efforts greatly facilitated the study process. Chief Philip Michel of Brochet, Chief Jerome Denechezie of Lac Brochet and the Study Co-ordinators - Joe Michel (Brochet) and Adam Nalge (Lac Brochet) - were instrumental in initiating the study and providing much needed assistance at the local level. Representatives of Energy Mines and Resources Canada; Department of Indian and Northern Affairs; Manitoba Hydro; Manitoba Department of Northern Affairs; and Medical Services Branch of Health and Welfare Canada, graciously provided the study team with much needed information and directive feedback throughout the course of this assignment. This report is consequently the result of a collaborative effort geared to assessing the energy situation and potential at Brochet and Lac Brochet.

Map 1-1



Map 1-2


North
Cochrane River
Reindeer Lake
To Thompson
To Lynn Lake

2.

COMMUNITY BASE DATA - BROCHET

2. COMMUNITY BASE DATA - BROCHET

2.1 Background and History:

The Hudson's Bay Co. first established a post at the present site of "Brochet" on the north end of Reindeer Lake during the winter of 1808-09. In those days, Brochet was visited by Chipewyans who survived by utilizing the caribou herds which roamed the area. Due to the abundancy of caribou, the Chipewyans had little need or interest to trade furs for white man's goods and the post eventually became a meat depot and supplied other southern posts with caribou meat products. Gradually, however, the Chipewyans became accustomed to trade and a fur trade was eventually established.

Crees from the Peter Ballantine Band situated at the extreme southern tip of Reindeer Lake (Southend, Saskatchewan) came to Brochet along with the Hudson's Bay Co. and the Catholic Missionaries. It was primarily the Cree who first settled Brochet on a year round basis as the Chipewyans only visited the post a few times a year as dictated by the migrating caribou herds.

Adhesions to Treaty No. 10 to include the Lac du Brochet and Lac la Hache Bands of Chipewyans were signed in 1907. The Barren Lands Band was formally domiciled at Brochet and was included in treaty negotiations with the Lac la Hache Band from Wollaston Lake, Saskatachewan, who also traded at the Brochet post. At the time of population survey in 1929, performed to establish land entitlement, the travelling Chipewyans were also "given" a reserve at Brochet along with the stationary Cree.

2.1 con't

In 1964, an important Chipewyan leader moved to the Brochet settlement for age and health reasons. The Federal government began to build houses for treaty Indians living on reserve and some Chipewyan families began to move to the reserve at Brochet. After the commercial fishing season ended in 1964, many of the Chipewyan families stayed at Brochet for their first winter. Only the men and older boys went north to hunt and trap. By the 1967 hunting season, almost all Chipewyans stayed in Brochet and only a few individuals went north.

All the Crees and Chipewyans in the area lived together at Brochet until 1973. At that time, approximately 10 Chipewyan families moved to a location 75 miles north, situated on Lac Brochet. Two years later, 1975, almost all remaining Chipewyans at Brochet moved to join the initial migratory group and established the settlement now known as "Lac Brochet". The reasons most often cited for this separation involve a basic incompatibility between the Crees and Chipewyans, and, the Chipewyans' continued utilization of the caribou herds which moved farther north in the interim.

On April 27, 1976, the Barren Lands Band was formally granted a reserve pursuant to the Indian Act. Brochet Indian Reserve No. 197 consists of 10,719 acres based upon a 1970 resurvey of the reserve.

2.2 General Characteristics

2.2.1 Community Structure:

Brochet is comprised of a Treaty Indian and Metis community situated on the northern shore of Reindeer Lake, approximately 72 air miles north of Lynn Lake. The total population of Brochet is approximately 600 and is composed of 295 Treaty, 267 Metis and 20 - 30 non-natives.

The three population components remain fairly distinct and separate. The Treaty Indian component is governed by an elected Chief and Council. The non-Treaty community is represented by an elected Mayor and Community Council. While each elected body operates independently of the other, the two community components usually co-operate with each other as warranted by situational events.

Any potential developments which therefore affect the entire community (both Treaty and Non-Treaty) will require ratification and support from both elected authorities as well as the general population.

2.2.2 Transportation:

As is readily observable, Brochet is isolated in terms of economical access to larger centres in northern Manitoba such as Lynn Lake, Flin Flon and Thompson. The nearest road/rail connection is Lynn Lake, situated some 72 miles to the south. Personal travel is effected by regularly scheduled flights providing air linkage to Lynn Lake, Thompson and beyond.

Notwithstanding the expense associated with flying whenever a personal trip to a larger centre is required, the tremendous expense involved in freighting goods to Brochet is most critical when considering community operations and potential development. The only "overland" transportation route involved the utilization of "cat-trains" over frozen Reindeer Lake during the winter road season, February to April depending upon conditons. Items to be transported were first shipped to Lynn Lake and marshalled for further conveyance. Goods were transported via road to Co-op Point and then, finally, loaded onto diesel tractors and shipped over the frozen lake to Brochet.

1981-82 was the last year for "cat-train" operation and Brochet obtained a temporary winter road connection during the 1982-83 season. The winter road enables normal trucking vehicles to drive directly to Brochet from Lynn Lake (or further). The route over frozen Reindeer Lake is developed and maintained as a "road" constructed of ice as opposed to a "trail" which was used by the cat trains. The proper winter road eliminates the materials handling which was necessary for cat train operation. Continued winter road utilization was undetermined at the time of writing this report.

Even though winter road operations are more economical than cat trains, winter road transportation costs are still extremely high when considering that the 72 mile trip from Lynn Lake to Brochet cost $5.25/mile in 1982/83. This price is anywhere from 4 to 7 times higher than the transportation rate in more accessible areas of the Province.

The most expensive transportation alternative available to the community involves flying in goods from Lynn Lake and Thompson. Fuel oil transported via aircraft fitted with an interior bladder costs 31¢ per litre plus 11.9¢/l shipping charge from Thompson, Manitoba. If sufficient fuel is unavailable at Thompson, fuel will be flown in from Lynn Lake or Gillam at slightly higher cost. On average, the aircraft so utilized can carry 4,000 gallons of fuel oil, which amounts to approximately 7,000 pounds, and a shipping charge of 7¢ per pound. In comparison, the aforementioned winter road route enables 30,000 pounds of freight, on average, to be shipped for a total cost of $1,315 (125 mi. x 2 x $5.25/mi) or a unit cost of 4 1/2¢ per pound ($1,315 / 30,000).

In summer, goods may be transported to Brochet via barge from Co-op Point. Again, costly materials handling is evident when considering the loading and unloading required with this method of transportation.

Both the winter road and summer barge routes are entirely dependent upon favourable weather conditions. Transport costs vary from year to year (usually increase) depending upon general conditions. Non-shipment of goods is always possible in view of uncertain conditions.

Any development requiring construction and on-going supply/maintenance must consider the transportation considerations presented herein. Wherever possible, materials should be transported via winter road and securely stored until required.

2.2.3 Economy:

The community of Brochet suffers from a general lack of economic activity and a resultant scarcity of employment opportunities.

The local Native population, both Treaty and Metis, are the population component directly affected by this economic condition. Apart from seasonal fishing, hunting or trapping activities, the Brochet Native population mostly survives on social assistance payments. More than one-half of the local Metis workforce of approximately 60-70 individuals requires social assistance to survive. The Barren Lands Band administers social assistance to its members and records show that approximately 47 members on average receive social assistance every month throughout the fiscal year. Social assistance requirements peak during the winter months with approximately 65-70 members out of a 295 Band population receiving such assistance.

The non-Native population, on the other hand, is fully employed. This is logical when considering that most non-Natives come to Brochet to take advantage of specific job opportunities requiring skill or education levels hitherto unattained by any local residents.

The largest employer in Brochet is the Frontier School Division, which owns and operates a 25,155 square foot school facility in the community. The school employs 14 non-Native teachers who are housed in Division housing and 9 additional employees obtained from the Native population.

The Hudson's Bay Company employs a non-Native manager who is essentially responsible for entire outlet operations.

The company employs 5 - 8 local individuals on both a full time-part time basis to assist with receiving, stocking, sales and shipping.

The Medical Services Branch nursing station employs two (2) full time non-Native nurses to provide general health care to the local population. A few local individuals are retained to provide cleaning services and generally assist the nurses.

The Manitoba Department of Transport employs a non-Native individual to manage the local airstrip and related facilities. Two (2) locals are employed on a part time basis to generally assist the airport manager.

The Oblate Fathers operate a Catholic mission which requires the services of two (2) priests and a nun.

The Royal Canadian Mounted Police employ one (1) non-Native constable who provides the community with law enforcement services.

A local Native individual is employed by Manitoba Hydro to generally operate the diesel generation facilities.

Any work requiring highly skilled or highly trained expertise in, for example, diesel repairs, telephone dish repairs, etc., is satisfied by flying in individuals from Lynn Lake and beyond. The community is often

without phone service, for example, until such time as a technician is able to arrive from the southern portions of the Province.

Most local male Natives partake of traditional seasonal activities such as fishing, hunting and trapping. Trapping does not generate more than minimal amounts of cash income when considering average yields and prices over the past years. Fishing and hunting are now undertaken primarily as a means of food procurement and may not be considered a commercial endeavour. A few Native individuals are retained as guides in the summer months by a tourist lodge situated to the south on Reindeer Lake.

No other local employment opportunities are presently available to members of the Brochet community. Consequently, some families do move to larger centres such as Lynn Lake, Thompson and beyond, in search of employment. Of those who remain, however, the vast majority are unemployed.

2.3 Brochet Community Survey

A household survey was prepared in order to obtain more specific information about the community and its energy requirements. The survey was approved by the Barren Lands Band, E.M.R. and DIAND prior to distribution. A newsletter was first distributed to inform residents of the upcoming survey and to elicit cooperation. The Local Co-ordinator, a member of the Barren Lands Band, then visited each household to obtain responses to the structured survey format.

The following interpretive comments illustrate the major findings of the survey:

Housing:

- Brochet is comprised of three (3) major population groups, namely Brochet Treaty (BT), Brochet Metis (BM) and Brochet Non-Native (BN).

- Almost all housing is frame type, single storey. 60% of BT homes are at least 10-14 years old, 72% of BM homes are at least 10-14 years old, while almost all BN homes are 10-15 years old.

- 28% BT homes, 17% BM homes and 14% BN homes contained R-20 insulation throughout. All remaining homes contained R-12 insulation throughout.

- BT homes average occupancy is 5.9 people, BM homes average 6.5 people while BN homes average 2.3 people.

- Almost all BT/BM homes do not have adequate weather stripping on doors, hatches, etc. Most BN homes have adequate weatherstripping.

- Almost all respondents' homes contained either 100 amp. or 125 amp. electrical boxes. Most respondents use a dual 15 amp. breaker as per Manitoba Hydro restrictions.

- Respondents' possession/use of electrical appliances:

	BT	BM	BN
Refrigerator	52%	81%	100%
Toaster	44%	72%	86%
Toaster Oven	0%	25%	100%
Freezer	32%	67%	71%
Television	25%	100%	100%

Housing (con't)	BT	BM	BN
Radio	68%	75%	14%
Washing Machine	60%	83%	29%
Dryer	16%	19	29%
Regular Stove	8%	16%	86%
Hot Plate/Small Stove	60%	72%	29%
Stereo	56%	67%	71%

- Virtually all BT/BM respondents use wood for home heating. The majority of BT/BM homes utilize airtight stoves capable of burning 2' logs for this purpose.

- BT respondents consume an average 9 boat loads and 36 skidoo loads of wood per year. BM respondents consume 7 boat loads and 33 skidoo loads of wood per year. Discussions with townspeople indicate that conversion of boat/skidoo loads to cords is highly subjective. Specific discussion on wood utilized is presented elsewhere in this report.

- Poor heat distribution is a major problem in BT/BM homes.

- Almost all BT/BM homes would convert to electric heat, electric water heater, large stove/oven and clothes dryer if electrical power were available at user costs equivalent to present energy procurement costs.

Community Participation

- Most BT respondents received less than a Grade 9 education, most BM respondents received less than Grade 10, while most BN respondents had vocational and/or university training.

- Unemployment for BT respondents is conservatively estimated at 64% of the labour force while BM unemployment approached 56%. BN respondents were mostly fully employed.

- Almost all BT, BM and BN respondents would support proposed hydro development and transmission line clearing providing environmental impact was minimal.

2.4 Population Characteristics & Projections

2.4.1 Brochet Treaty

The following tables present a detailed population analysis of the Barren Lands Band as per the latest available band list at the time of writing this report. Population levels by age and sex are given for the total Barren Lands Band membership as well as those living on and off the Barren Lands Reserve.

The total population (December 31, 1982) as presented by D.I.A.N.D. identifies 363 individuals listed as members of the Barren Lands Band. Of this total, roughly 14% of the population is pre-school age (0-4), 37% school age (5-15), 46% labour force (16-64) and 3% (65+) elderly.

Some 257 listed members of the Barren Lands Band reside within the boundaries of the reserve. At the time of writing this report, the Barren Lands Local Co-ordinator indicated that the Barren Lands Reserve accommodated registered Barren Lands as well as Northlands Band members. This is due primarily as a result of the recent establishment of Lac Brochet and will take time to resolve itself.

Medical Services Branch - Manitoba Region, was approached to provide their latest available estimates of Barren Lands Band population in order to verify the Indian Affairs Band list. As of July 21, 1983, Medical Services Branch records indicate a Barren Lands on-reserve population of 330 members and an off-reserve population of 73 members for a total of 403. The discrepancy between Medical Services and Indian Affairs estimates probably reflects an additional year of population growth (1982 to 1983), the aforementioned inter-Band settlement and some confusion between Brochet Treaty and non-status natives.

It is important to note that the Barren Lands Band population is fairly young with 71% - 72% of the population (both Indian Affairs and Medical Services data) of the on-reserve population being under the age of 25. This characteristic reflects the Band's tendency to large families and is consistent with age characteristics of other Bands.

Indian Affairs data, Table 2-2 suggests an average on/off reserve ratio of 73.14% on-reserve, 14.36% off-reserve and 12.50% on crown land. These ratios were determined by averaging Indian Affairs population data back to 1970.This data includes the years before, during and after the split with the Northlands Band which began in 1974. The resulting average on/off ratios therefore depict a somewhat lower figure for on-reserve population than is presented for 1983. This lower on-reserve ratio was utilized for purposes of projection.

For purposes of projection, the current Medical Services population estimate of 403 Barren Lands Band members was applied to the above on/off crown ratios. This higher total estimate provides a contingency measure so as not to project too low a population in respect of potential hydro resource development.

Population projections are subjective at best and merely attempt to provide an indication as to what growth patterns could reasonably be expected to occur within the projected time horizon. Trend analysis, coupled with the particular characteristics of the population group being studied are the methodologies most widely used in this regard.

As per the accompanying Table 2-1 depicting the Band's population levels from 1970 to the present, the average rate of growth experienced by the Barren Lands Band to date has approached 4.2% per annum. Assuming no external influences of a significant nature, given the isolated location, and in view of the present lack of employment/ development opportunities at the local level, the present growth rate of 4.2% per annum was utilized for purposes of this analysis. Growth rates utilizing 3.7% per annum and 4.7% per annum are also presented to reflect a possible range of population growth. See Tables 2-3 and 2-4.

TABLE 2-1

Barren Lands
Total Population
1970 - 1983

YEAR	ON RESERVE	OFF RESERVE	CROWN LAND	TOTAL	% CHANGE
1970	470	19	37	526	
1971	489	19	36	544	3.42
1972	438	49	71	558	2.57
1973	452	61	80	593	6.27
1974	423	32	159	614	3.54
1975	331	46	266	643	4.72
1976	345	55	272	672	4.51
1977	361	52	279	692	2.98
1978	373	54	265	692	.00
1979	240	40	53	333	.00
1980	237	36	63	336	.90
1981	245	54	49	348	3.57
1982	257	56	50	363	4.31
1983	330	73	-	403	11.02
Avg Growth 1971-78	3.50				
Avg Growth 1979-83	4.95				
Avg Growth 1971-83	4.23				

* Split 1974

TABLE 2-2

Barren Lands
On/Off Ratios
1970-1983

Year	Percent ON RESERVE	Percent OFF RESERVE	Percent CROWN LAND	Total
1970	89.35	3.61	7.03	100
1971	89.89	3.49	6.62	100
1972	78.49	8.78	12.72	100
1973	76.22	10.29	13.49	100
1974	68.89	5.21	25.90	100
1975	51.48	7.15	41.37	100
1976	51.34	8.18	40.48	100
1977	52.17	7.51	40.32	100
1978	53.90	7.80	38.29	100
1979	72.07	12.01	15.92	100
1980	70.54	10.71	18.75	100
1981	70.40	15.52	14.08	100
1982	70.80	15.43	13.77	100
1983	81.89	18.11	.00	100
Avg 1979-83	73.14	14.36	12.50	100

TABLE 2-3

Barren Lands
Pop. Projections
1983 Base Year

Year	3.7% Growth	4.2% Growth	4.7% Growth
1983 base	403	403	403
1984	418	420	422
1985	433	438	442
1986	449	456	463
1987	466	475	484
1988	483	495	507
1989	501	516	531
1990	520	538	556
1991	539	560	582
1992	559	584	609
1993	580	608	638
1994	601	634	668
1995	623	660	699
1996	646	688	732
1997	670	717	767
1998	695	747	803
1999	721	778	840
2000	747	811	880
2001	775	845	921
2002	804	881	964
2003	833	918	1010
2004	864	956	1057
2005	896	996	1107
2006	929	1038	1159
2007	964	1082	1213
2008	999	1127	1270
2009	1036	1175	1330

TABLE 2-4

BARREN LANDS
POP. PROJECTIONS
ASSUME 4.2% GROWTH

YEAR	ON-73.14%	OFF-14.36%	CROWN-12.5%	TOTAL
1983 base	295	58	50	403
1984	307	60	52	420
1985	320	63	55	438
1986	333	65	57	456
1987	347	68	59	475
1988	362	71	62	495
1989	377	74	64	516
1990	393	77	67	538
1991	410	80	70	560
1992	427	84	73	584
1993	445	87	76	608
1994	463	91	79	634
1995	483	95	83	660
1996	503	99	86	688
1997	524	103	90	717
1998	546	107	93	747
1999	569	112	97	778
2000	593	116	101	811
2001	618	121	106	845
2002	644	126	110	881
2003	671	132	115	918
2004	699	137	120	956
2005	729	143	125	996
2006	759	149	130	1038
2007	791	155	135	1082
2008	824	162	141	1127
2009	859	169	147	1175

2.4.2 Brochet Metis

Brochet Metis population was not described by any institutional sources at the time of writing this report. While not exactly compatible with Indian Affairs/Medical Services data, the local survey data indicates that the Brochet Metis population is fairly consistent with the Treaty population in terms of age characteristics.

Given the close proximity of the Metis population to the Treaty population, the level of intermarriage of the two groups and the inter-relatedness of economic potential, the Brochet Metis should parallel Brochet Treaty in terms of growth. The accompanying Table 2-5 on page 25 therefore depicts a median growth rate of 4.2%, and a range of 3.7% to 4.7% per annum.

2.4.3 Brochet Non-Native

At present, non-Natives travel to pursue specific job opportunities. The survey identified some 13 non-Natives employed by Frontier School, Medical Services, Hudson's Bay, etc. Discussions with the local co-ordinator indicate that approximately 20 non-Natives presently live at Brochet. These 20 non-Natives are economically related to the total Native population of 562, (295 Treaty and 267 Metis), in terms of support services. It is therefore reasonable to assume that if the Native population doubles, for example, the non-Native support service component could also double. As the Native population will double by the year 2000, assuming median

TABLE 2-5

Brochet Metis
Pop. Projections
1983 Base Year

Year	3.7% Growth	4.2% Growth	4.7% Growth
1983 base	267	267	267
1984	277	278	280
1985	287	290	293
1986	298	302	306
1987	309	315	321
1988	320	328	336
1989	332	342	352
1990	344	356	368
1991	357	371	386
1992	370	387	404
1993	384	403	423
1994	398	420	443
1995	413	437	463
1996	428	456	485
1997	444	475	508
1998	460	495	532
1999	477	516	557
2000	495	537	583
2001	513	560	610
2002	532	583	639
2003	552	608	669
2004	573	633	700
2005	594	660	733
2006	616	688	768
2007	639	717	804
2008	662	747	842
2009	687	778	881

growth, the non-Native professional support component could reach 40 individuals. This non-Native growth estimate could be drastically reduced, however, if local residents were to undergo appropriate training and provide many of the services now provided by non-Natives.

In view of the uncertainty associated with non-Native growth and given the relatively small non-Native population component as compared to the local Native population, non-Native population growth was <u>not</u> projected for purposes of this study.

3.

LAC BROCHET

3. LAC BROCHET

This section of the report presents base data for the community of Lac Brochet, Manitoba.

3.1 Background and History:

As mentioned previously in this report, the settlement of Brochet was first established by the Hudson's Bay Company in order to trade with the many Chipewyans who roamed the area while utilizing the Caribou herds for survival. Crees from Southend, Saskatchewan accompanied Hudson's Bay officials and missionary representatives to Brochet. The Chipewyans first began to settle year round in Brochet in 1964.

All Crees and Chipewyans in the area lived together at Brochet until 1973. At that time, approximately 10 Chipewyan families moved to a location 70-80 miles north, situated on Lac Brochet. Two years later, 1975, almost all remaining Chipewyans at Brochet moved to join the initial migratory group and established the settlement now known as "Lac Brochet". The reasons most often cited for this separation involve a basic incompatibility between the Crees and Chipewyans, and the Chipewyans' continued utilization of the Reindeer herds which moved farther north in the interim.

In 1976 the Northlands Band was formally granted a reserve, 197A, pursuant to the Indian Act.

3.2 General Characteristics:

3.2.1 Community Structure

Lac Brochet is comprised of a Treaty Indian community situated on Lac Brochet Lake, approximately 96 air miles north of Lynn Lake. The total population of Lac Brochet is approximately 450 and is composed of 437 Treaty and 10-15 non-Natives.

The two population components remain distinct as the non-Natives are primarily in Lac Brochet as a result of specific employment opportunities while the Treaty people have established Lac Brochet as their home.

The Northlands Band Chief and Council are the main administrative body which governs the community of Lac Brochet. Any potential developments which affect Lac Brochet will therefore require Chief and Council ratification.

3.2.2 Transportation

Lac Brochet faces a transportation situation which is almost identical to Brochet. Almost all bulk goods and materials are shipped through Lynn Lake, which is the nearest road/rail connection situated some 96 miles to the south.

Up until 1981-82, goods shipped in the winter were transported via "cat-train" over trails on frozen Reindeer Lake and on up to Lac Brochet Lake. A winter road to Lac Brochet was constructed and utilized for the first time during the winter of 1982-83. The winter road season generally runs from February to April, depending upon prevailing conditions.

Other than winter road, the only other transportation mode to Lac Brochet is via airplane. Goods and fuel are flown in to Lac Brochet regularly from Lynn Lake.

Barge service is not available at Lac Brochet.

Transportation prices to Lac Brochet are similar to fees discussed for Brochet.

Transportation to Lac Brochet is even more critical when considering the unavailability of barge service. Construction hoarding and on-going supply maintenance must be accounted for when considering any proposed development.

3.2.3 Economy:

Lac Brochet also suffers from a scarcity of economic activity and a resultant lack of employment opportunities. Furthermore it is the local Treaty population which is directly affected by this economic condition. Seasonal fishing, hunting and trapping notwithstanding, the Lac Brochet Treaty population also survives mostly on social assistance payments. While specific information was not available at the time of writing this report, if the Northlands Band's situation is indeed similar to the Barren Lands Band, then more than one-half of the Northlands work force requires social assistance to survive.

The non-Native population is fully employed. This is again reasonable when considering that most non-Natives came to Lac Brochet to pursue specific employment opportunities requiring skill or education levels hitherto unattained by any local residents.

The largest employer in Lac Brochet is the school which is run under the auspices of Indian Affairs Canada. Medical Services and the Manitoba Department of Transport are probably the next largest employer of non-Natives and Treaty alike.

A local Native individual is employed by Manitoba Hydro to generally operate the diesel generation facilities.

Any work requiring skilled or highly trained expertise in, for example, diesel repairs, telephone dish repairs, etc., is satisfied by flying in individuals from Lynn Lake and beyond. The community is often without phone service, for example, until such time as a technician is able to arrive from the southern portion of the province.

As mentioned previously, most local male Natives partake of traditional seasonal activities such as fishing, hunting and trapping. Trapping does not generate more than minimal amounts of cash income when considering average yields and prices over the past years. Fishing and hunting are now undertaken primarily as a means of food procurement and may not be considered as commercial endeavours.

No other local employment opportunities are presently available to members of the Brochet community. Consequently some families move to larger centres such as Lynn Lake, Thompson and beyond, in search of employment. Of those who remain, however, the vast majority are unemployed.

3.3 Lac Brochet Survey

Similar to Brochet, a local survey was conducted to obtain relevant information at the community level. The survey was approved by the Northlands Band, E.M.R. and D.I.A.N.D. prior to distribution. A newsletter was first distributed to inform residents of the upcoming survey and to elicit co-operation. The Local Co-ordinator, a member of the Northlands Band, then visited each household to obtain responses to a structured survey format. The following interpretive comments illustrate major survey findings:

3.3.1 Housing:

- Lac Brochet population is Treaty Indian. Non-Native inhabitants fill professional employment positions. Survey results are generally similar to Brochet.

- Housing is predominantly frame type, single storey. Most homes have been constructed within the past 12 years due to the recent establishment of the community.

- 54% of respondents' homes contained R-20 insulation throughout while the remainder contained R-12.

- Average occupancy is 5.7 people.

- Most homes have adequate weather stripping on doors, hatches, etc.

- 125 amp., 100 amp. and 120 amp. electrical boxes are utilized along with dual 15 amp. breakers.

3.3.1 con't

- respondents' possession/use of electrical appliances:

Refrigerator	19%
Toaster	63
Toaster Oven	14
Freezer	53
Television	14
Radio	72
Washing Machine	53
Dryer	11
Regular Stove	19
Hot Plate/Small Stove	72
Stereo	100

- virtually all respondents use wood for home heating

- no data for heat source (wood) consumption or cost was available

- almost all respondents would convert to electric heat, electric hot water heater, large stove/oven and clothes dryer if electrical power were available at user costs equivalent to present energy procurement costs

3.3.2 Community Participation:

- no human resources data was obtained via survey. However, conditions for Lac Brochet should be similar to Brochet

3.4 Population Characteristics & Projections:

3.4.1 Lac Brochet Treaty:

The following tables and charts present a detailed population analysis of the Northlands Band as per the latest available Band list at the time of writing this report. Population levels by age and sex are given for the total Northlands Band membership as well as those living on and off the Northlands Reserve.

The total population (December 31, 1983) as presented by DIAND identifies 433 individuals listed as members of the Northlands Band. Of this total, roughly 16% of the population is pre-school age (0-4), 28.5% school age (5-15), 48.5% labour force (16-64) and 7% (65+) elderly.

Some 418 listed members of the Northlands Band reside within the boundaries of the Reserve or on nearby Crown Land. At the time of writing this report, the Local Co-ordinator indicated that the Northlands Reserve accommodated Barren Lands as well as Northlands Band members. This is due primarily to the recent establishment of Lac Brochet and will take time to resolve itself.

Medical Services Branch - Manitoba Region, was approached to provide their latest available estimates of Northlands Band population in order to verify the Indian Affairs Band list. As of July 21, 1983, Medical Services Branch records indicate a Northlands on-Reserve population of 366 members and an off-Reserve population of 71 members, for a total of 437. The discrepancy between the two <u>total</u> estimates of population provided by Indian Affairs

3.4.1 con't

and Medical Services is insignificant. The discrepancy pertaining to on-reserve population probably reflects an additional year of population growth (1982 to 1983) and the inter-Band settlement involving the establishment of Lac Brochet.

It is important to note that the Northlands Band population is also fairly young. This is consistent with age characteristics for both Brochet Treaty and Brochet Metis. Approximately 66% of the Northlands Band population is under the age of 25. This also reflects the Band's tendency to large families.

Indian Affairs data, Table 3 suggests an average on/off reserve ratio of 93.8% on-Reserve, including nearby Crown Land which has recently been converted to reserve, and, 6.2% off-reserve. It is important to note that the large numbers of Crown Land residents reside primarily on nearby land set aside for the Northlands Band and, as such may be considered as on-reserve residents for purposes of projection.

For this report, the current Medical Services total population estimate of 437 Northlands Band members was utilized and applied to the above on/off ratios. This higher estimate provides a contingency measure so as not to project too low a population in respect of potential Hydro resource development.

Population projections for the Northlands Band were estimated on a similar basis to those presented for the Barren Lands Band.

3.4.1 con't

As per the accompanying table 3-1, depicting the Band's population levels from 1979 to the present, the average rate of growth experienced by the Northlands Band to date has approached 3.3% per annum. Assuming no external influences of a significant nature, given the isolated location, and in view of the present lack of employment/ development opportunities at the local level, the present growth rate of 3.3% per annum was utilized for purposes of this analysis. Growth rates of 2.8% and 3.8% are also presented to reflect a possible range of population growth, see Tables 3-3 and 3-4.

Table 3-1

Northlands

Total Population
1979-83

YEAR	ON RESERVE	OFF RESERVE	CROWN LAND	TOTAL	% CHANGE
1979	147	13	224	384	0
1980	151	15	228	394	2.60
1981	162	17	234	413	4.82
1982	172	15	246	433	4.84
1983	366	71	0	437	.92
Avg Growth 1979-83	3.30				

Table 3-2

Northlands
On/Off Ratios
1979-83

Year	Percent ON RESERVE	Percent OFF RESERVE	Percent CROWN LAND	TOTAL
1979	38.28	3.39	58.33	100
1980	38.32	3.81	57.87	100
1981	39.23	4.12	56.66	100
1982	39.72	3.46	56.81	100
1983	83.75	16.25	.00	100
Avg 1979-83	47.86	6.20	45.93	100

Northlands
Pop. Projections
1983 Base Year

Table 3-3

Year	2.8% Growth	3.3% Growth	3.8% Growth
1983 base	437	437	437
1984	449	451	454
1985	462	466	471
1986	475	482	489
1987	488	498	507
1988	502	514	527
1989	516	531	547
1990	530	549	567
1991	545	567	589
1992	560	585	611
1993	576	605	635
1994	592	625	659
1995	609	645	684
1996	626	666	710
1997	643	688	737
1998	661	711	765
1999	680	735	794
2000	699	759	824
2001	718	784	855
2002	739	810	888
2003	759	837	921
2004	780	864	956
2005	802	893	993
2006	825	922	1030
2007	848	953	1070
2008	872	984	1110
2009	896	1016	1152

Table 3-4

Northlands
POP. PROJECTIONS
ASSUME 3.3% GROWTH

YEAR	ON-93.8%	OFF-6.2%	CROWN-00.0%	TOTAL
1983 base	410	27	0	437
1984	423	28	0	451
1985	437	29	0	466
1986	452	30	0	482
1987	467	31	0	498
1988	482	32	0	514
1989	498	33	0	531
1990	515	34	0	549
1991	531	35	0	567
1992	549	36	0	585
1993	567	37	0	605
1994	586	39	0	625
1995	605	40	0	645
1996	625	41	0	666
1997	646	43	0	688
1998	667	44	0	711
1999	689	46	0	735
2000	712	47	0	759
2001	735	49	0	784
2002	760	50	0	810
2003	785	52	0	837
2004	811	54	0	864
2005	837	55	0	893
2006	865	57	0	922
2007	893	59	0	953
2008	923	61	0	984
2009	953	63	0	1016

4.

STUDY REGION FUTURE GROWTH POTENTIAL

4. STUDY REGION FUTURE GROWTH POTENTIAL

The previous section of this report was used to provide engineering study team members with community base data so as to describe existing energy requirements. This section of the report utilizes the aforementioned base data in an attempt to predict future growth in the Brochet-Lac Brochet study region. Future growth will then be presented in terms of energy requirements and related to potential energy alternatives.

Future growth is seen as occurring in three broad areas; population, social/support development and economic development. Population growth will occur whether additional electrical resources are developed or not. Median population growth rates have been utilized to reflect past growth trends. Electrical resource enhancement will be a necessary pre-requisite if the potential social support and economic developments discussed herein are to have enough energy resources to be considered. It is also assumed that the area population will continue to settle Brochet and Lac Brochet and will not experience significant migration.

It is important to note that future growth estimates are highly subjective at best. Growth projections were estimated on the basis of experience with other northern locations and similar population levels. The resultant population, housing and energy projections are therefore indicative but must not be construed as definitive. General consensus regarding the growth rates presented herein was achieved via discussions with DIAND - Planning Section and Manitoba Northern Affairs.

It is critically important for the Barren Lands and Northlands Bands to realize that these future growth estimates are <u>not</u> recommended for future development in the area. These merely suggest

reasonable developments which may naturally evolve if sufficient energy resources are available. These growth estimates do not have formal departmental (DIAND and EMR) approval for potential funding and are presented for study purposes only.

4.1 Population Growth:

The preceding sections on study area population present various ranges of population growth affecting Brochet Treaty, Brochet Metis and Lac Brochet Treaty members. Study region population projections on Table 4-1, were determined by combining the median population growth rates of the three major population groups. The projections reflect study area populations only in that on-reserve and nearby Metis settlement ratios are identified in Table 4-1. In view of the uncertainty associated with continued non-Native employment and levels of support funding, the non-Native population was not included in study region projections. It is felt that the contingencies incorporated in the base population levels utilized for projection should accomodate non-Native growth potential.

The following study region population projections were taken from the accompanying Table 4-1:

Years From Present	Projection Year	Barren Lands	Brochet Metis	North lands	Study Region Total Population
5	1988	362	328	482	1,172
10	1993	445	403	567	1,415
15	1998	546	495	667	1,708
20	2003	671	608	785	2,064
25	2008	824	747	923	2,494

The above population estimates form the basis for ensuing area development requirements and predictions.

Table 4-1

Study Region
Pop. Projections
1983 Base Year

Year	Barren Lands 4.2% Growth 73.14% On Res.	Brochet Metis 4.2% Growth	North Lands 3.3% Growth 93.8% On Res.	Study Region Projected Total Pop.
1983 base	295	267	410	972
1984	307	278	423	1008
1985	320	290	437	1047
1986	333	302	452	1087
1987	347	315	467	1129
1988	362	328	482	1172
1989	377	342	498	1217
1990	393	356	515	1264
1991	410	371	531	1312
1992	427	387	549	1363
1993	445	403	567	1415
1994	463	420	586	1469
1995	483	437	605	1525
1996	503	456	625	1584
1997	524	475	646	1645
1998	546	495	667	1708
1999	569	516	689	1774
2000	593	537	712	1842
2001	618	560	735	1913
2002	644	583	760	1987
2003	671	608	785	2064
2004	699	633	811	2143
2005	729	660	837	2226
2006	759	688	865	2312
2007	791	717	893	2401
2008	824	747	923	2494
2009	859	778	953	2590

4.2 Social/Support Development

The projected population will require social/support and related infrastructure developments in order to adequately sustain itself. The potential developments discussed herein reflect these maintenance and infrastructural requirements.

Housing

As the study region population increases, the number of housing units accommodating families will have to follow suit. The following table assumes that average house occupancy ranges from present levels of approximately 5.8 to 6.0 people per house as applied to study region population projections:

Table 4-2

Years From Present	Projection Year	Study Region Total Population	Housing Units Required Occupancy/House 5.8 Persons	6.0 Persons
Base	1983	972	136	
5	1988	1,172	202	195
10	1993	1,415	244	236
15	1998	1,708	294	285
20	2003	2,064	356	334
25	2008	2,494	430	416

From the results of the housing survey, each house could eventually contain or provide for:

- size will range from 800 s.f. to 1,100 s.f.
- wood/electric heat system
- breaker size to permit simultaneous use of appliances
- electric hot water heater 30-40 gallons
- regular stove/oven combination
- eventually a toaster oven, microwave or both
- electric clothes dryer
- electric washing machine
- large refrigerator
- freezer
- television, stereo
- miscellandous appliances

At present, most houses have no more than R12 or R20 insulation, no weather stripping, poorly fitting doors/windows, double pane windows. Future housing could more readily conform to energy efficient standards by utilizing more than R20 insulation, applying weather stripping, making sure doors/windows fit properly, utilizing triple pane windows, etc. Such standards, construction techniques and training require development for implementation by the communities.

Community Water System:

The housing surveys indicate that the communities would eventually desire a pressurized water system to provide water directly to each home. Brochet presently utilizes a community standpipe system which freezes during winter and still requires water to be hauled by pail. Lac Brochet has no water system of any kind and most residents must walk to the lake shore to haul water back to their homes. A standpipe system was being contemplated for Lac Brochet at the time of completing this report.

In view of the population and housing projections, a community water system would have to eventually service almost 1,600 people in Brochet and over 900 in Lac Brochet. The non-Native population could approach 40-50 in each community. In addition, the water system could probably also supply other developments including expanded education facilities, expanded medical facilities, administrative offices, community hall, elderly care facilities and perhaps some economic developments.

Energy requirements associated with community water systems for Brochet and Lac Brochet would include: a heated, lighted building housing all required pumps, filters, guages, etc.; energy to drive the pumps and other systems;

and sufficient energy to heat trace all water lines to prevent freezing in winter. A throughput allowance of 75 gallons per day, per person should describe plant capacity. Housing placement in both communities will have to become more concentrated and standardized in regular land subdivisions if a water system is to be economically justifiable.

The above requirements would have to be duplicated for each community and sized accordingly. Possible future expansion of the system should be accounted for.

Community Sewage Treatment:

The majority of residents in both communities utilize outdoor toilets and slop pails to treat effluent. A community sewage system was identified in the survey as being very desirable by community residents. The need for sewage treatment will become even more pressing as both communities continue to increase in population and place a greater strain on finite land and nearby potable water supply.

The sewage treatment system would have to service 1,600 people in Brochet and over 900 in Lac Brochet, along with 40-50 non-Natives in each community. Future social/support and possible economic developments must also be accounted for when determining size.

Energy requirements will depend upon the type of system eventually installed in each community. As a minimum, the sewage installation will require: a lighted, heated building, housing all pumps, filters and equipment; and energy to drive all associated motors, pumps and other systems. Similar to water usage, sewage plant capacity of 75 gallons per day, per person, should adequately treat effluent generated. Housing placement in both communities would have

to become more concentrated and standardized in regular land subdivisions if a sewage system is to be economically justifiable.

Medical Care:

Each community presently has a nursing station which is designed to meet the general health care needs of community residents. Each station contains basic medical equipment and is staffed by two (2) qualified nurses. Any serious illness or injuries are given preliminary treatment at the nursing station and are then flown out to Thompson or beyond.

The nursing stations at both Brochet and Lac Brochat are relatively new and should readily satisfy the general health care needs of the local populace for years to come. Projections indicate that the study region population will almost triple over the next 25 years. It is therefore assumed that the nursing stations in both communities will have to be expanded at some time during this period. Future energy requirements for expanded nursing stations, say double existing size to handle triple the population, should allow for electric/oil/wood heating, lighting and equipment operation.

Elderly Care:

At present, elderly people (65+) comprise only 4% of Brochet Treaty, 2% of Brochet Metis and 7% of Lac Brochet Treaty. Non-Natives are insignificant in terms of population considerations, and come to the study region to pursue specific employment opportunities and do not, as a rule, take up permanent residence in the study region. The

elderly in the region presently reside in their own domiciles or are looked after by younger family members.

Projections illustrate that the study region population could almost triple over the next 25 years. When considering the 40-60 age group of Brochet Treaty, Brochet Metis and Lac Brochet Treaty as per available information, it is apparent that the evolution of this age group will increase the number of elderly members by some 113 people by the year 2008, assuming no deaths. By applying a mortality rate of 20% to this estimate, the resultant elderly population would still amount to 90 individuals, almost three (3) times the number of elderly identified in current Band lists. Beyond this 25 year period, as younger members begin to age and improved living conditions/health care services continue to prolong life expectancy, there is every reason to expect the elderly population of the study region to increase significantly.

Both communities will therefore eventually require some facilities specifically designed for elderly care as not all elderly will be able to receive adequate care in the family setting.

Approximately 15-20 elderly care beds would eventually be required for Brochet while 10-15 care beds could be required in Lac Brochet. Allowing for 250 square feet of total area (bedroom, lounge, common areas, electrical/mechanical) per bedroom, Brochet could eventually construct a 9,000 square foot facility while Lac Brochet could construct a 3,700 square foot care facility. Each building would require heat, light and power for care equipment and mechanical systems.

Education:

Brochet has recently acquired a new school facility which is operated under the auspices of Frontier School Division. The 25,000 square foot facility accomodates Kindergarten through grade nine, and contains a gymnasium, home economics and industrial arts/woodworking facilities. The school age population at Brochet presently comprises some 130 Treaty children and 129 Metis children for a total school age population of 259.

Given the relatively young Brochet population and the tendency to large families, it was assumed that as the overall population doubles by the year 2000, the school age population will follow suit. In fact, school age population will probably more than double by the year 2000 given the large population bulge in the younger age categories currently experienced by the Brochet population. By the year 2000 Brochet may have a school age population well in excess of 550 students. Indian Affairs Canada standards allow for a maximum gross floor area of 45,730 square feet for a population of 550 students. This implies that an additional 20,000 square feet of school building would have to be constructed at Brochet if all students were to be accomodated locally.

Lac Brochet has school space amounting to approximately 6,000 square feet. The school is comprised of four (4) separate buildings containing two (2) classrooms each and is operated directly by Indian Affairs Canada. The school structures are barely adequate and do not meet usual building codes in terms of effluent treatment, etc. as outdoor toilets are still in use. The school contains no specialized facilities such as a gymnasium or industrial arts area.

Lac Brochet presently has about 120 school age children. Via similar assumptions presented for Brochet, it was assumed that the Lac Brochet school population could well exceed 250 students by the year 2000. Indian Affairs Canada standards allow for a maximum gross floor area of 21,800 square feet for 243 - 268 students. New construction for the entire 21,800 sq.ft. could be required given the conditions of present structures.

Community Complex/Administration:

Brochet does not presently contain adequate offices for either the Band or local council. The Band office is located in an abandoned house and does not have adequate heat, light or space. The consultants were not aware of any space available to accommodate the local council at the time of writing this report. The present community hall is an older structure which will not satisfy space requirements for much longer.

It was assumed that a local population approaching 1,100 to 1,600 over the next 20 to 25 years will require some sort of community complex containing a hall, offices and perhaps housing a fire pumper truck, etc. A 6,000 square foot specifically designed structure should readily satisfy community complex requirements at Brochet.

Similar consideration should also be given Lac Brochet. As projected, Lac Brochet's population could approach 800 to 900 over the next 20 years. A similar complex comprising 4,000 square feet should satisfy administration/community hall requirements at Lac Brochet.

Transportation:

As the area population will almost triple over the next 25 years, existing air terminal facilities will have to be expanded to more readily accommodate anticipated airline passengers. A 2,500 square foot structure will probably be required at Brochet.

Lac Brochet could probably utilize a 1,500 square foot terminal as its population increases.

Both communities rely heavily upon the winter road for bulk materials transport. Proper unloading/loading facilities are not available in either community and should be considered. Heated warehouse space in both communities would provide for storage until such time as materials, etc. are picked up or used. Some 5,000 square feet at Brochet and 3,500 square feet at Lac Brochet, complete with heat, light, power, etc. were considered adequate.

4.3 Economic Development

Study region poulation growth may generate economic development opportunities which are presently not justifiable from an economic viewpoint due to the high cost of energy infrastructure.

In almost all instances, the main target market opportunity for Brochet and Lac Brochet is their own population area. Brochet and Lac Brochet are too isolated to consider the competitive "import" of raw materials and the "export" of finished goods to other regions of the province. Almost all of the potential developments discussed herein attempt to provide goods and services to the local population on a commercial basis.

Store/Shopping:

Brochet presently has a Hudson's Bay Company outlet which contains approximately 2,500 to 3,000 square feet. The Hudson's Bay store provides dry food shopping, frozen food/meat products, drinks and snacks, hardware, clothing, recreational goods and other miscellaneous items. It was observed that the Hudson's Bay store was/is fairly busy as this is the only retail outlet in the community.

As the Brochet population triples over the next 25 years, the demand for retail products and hence retail space requirements will increase. An expansion of 2,500 to 3,000 square feet of food/retail space will probably be required to accommodate the increased demand generated by anticipated population increases.

Capital costs could approach the following:

Building 2,500 square feet @ $75	$187,500
Equipment and Fixtures	75,000 - 90,000
Infrastructure Hook-Ups	10,000 - 15,000
Capital Cost Estimate - Brochet	$272,500 - $292,500

The basic building cost estimate of $75 per square foot assumes local labour and winter road transport. Building cost allowances may be somewhat low when considering that building costs in other remote locations have exceeded $100 per square foot. Equipment and fixtures will include such items as display shelves, freezers, coolers, cash register, counters and other similar items. Hook-up costs will allow for sewage, water and electrical connections assuming community infrastructure is in place. If community infrastructure is not in place, project costs will increase

dramatically in order to satisfy infrastructure requirements and environmental protection regulations.

Working capital would involve opening inventory of at least $50,000 and cash of $20,000, for a total project cost of $342,500 - $362,500 at Brochet.

The following preliminary operations simulation could apply to an additional store outlet at Brochet:

Brochet Store Expansion:	
Principal/Interest -	
$100,000 @ 12% over 15 years	$ 14,175
Other Costs:	
Wages - 3 employees @ $10,000	30,000
Utilities, etc.	20,000
Building Operation	10,000
Miscellaneous	10,000
Total	$ 84,175

Assume variable cost of 65%*

Required Break-Even Volume $\frac{\$84,175}{(100\% - 65\%)}$ = $240,500

* Sales 100% - Variable Cost % = Contribution
Contribution = Fixed Cost = Break Even Sales

The above volume amounts to approximately $1,000 per year per family (270 families in 2008) in terms of patronage, which is realistically attainable given an average family size of 5.8 persons. The expansion at Brochet could either be undertaken by Hudson's Bay due to that company's financial resources, or, could be established by the Band as a separate, competitive outlet supported by grant funds.

In order to achieve the above break even level, grants and equity of $250,000 or 71% of total costs would be required. This project could create 5 jobs and transfer these individuals from social assistance funding.

A band member in Lac Brochet has recently opened a store facility comprising some 2,000 square feet. The store offers the usual range of items including dry foods, frozen foods/meats, clothing, hardware, etc. As the Lac Brochet population increases, the Lac Brochet store may also undergo an expansion as a direct result of increased demand for store services.

In view of the smaller population of Lac Brochet expansion would probably involve only 1,000 square feet as follows:

Basic Building 1,000 sq.ft. @ $80		$ 80,000
Equipment & Fixtures	25,000 -	30,000
Infrastructure Hook-Ups		10,000
Capital Cost Estimate - Lac Brochet	$115,000 -	$120,000

Eighty dollars ($80) per square foot will allow for extra transportation costs to Lac Brochet. Equipment, fixtures and hook-up costs should not be too significant.

Working capital requirements could approach $30,000 in stock and $10,000 in cash for total project costs of $155,000 - $160,000.

The following preliminary operations simulation could apply to Lac Brochet:

Lac Brochet Store Expansion

Principal/Interest:	
$64,000 @ 12% over 15 years	$ 9,085
Other Costs:	
Wages 1 1/2 employees @ $10,000	15,000
Utilities, etc.	10,000
Building Operation & Miscellaneous	10,000
Total	$ 44,085

Assume Variable Cost of 65%
Required Break-Even Volume $\frac{\$44,085}{(100\% - 65\%)} = \$125,960$

This analysis assumes that grant and equity amounting to $91,000 or 59% of project costs would be available. This potential expansion could create 1 1/2 jobs.

The above volume amounts to approximately $965 per year per family (164 families in 2008) in terms of patronage, which is realistically attainable given an average family size of 5.8 persons.

Bakery

The Hudson's Bay Store and the grocery store at Lac Brochet presently provide all bread and bakery products sold in the two communities. Bread and bakery products are flown in from Lynn Lake on a regular basis and the price for a 450 gm. (16 oz.) loaf of bread is $1.09.

Consumption of bread in the southern portions of the province currently averages about 1-16 oz. loaf per person per week. Previous discussions with Hudson Bay Northern Stores representatives indicate that northern Manitoba consumption is higher, on average, at 1 1/2 - 16 oz. loaves of bread per person/week. The present study region therefore is estimated to consume approximately 1,500 - 16 oz. loaves of bread per week. Consumption of bread will increase dramatically as the study population increases and could reach almost 4,000 - 16 oz. loaves per week over the next 25 years.

This significant consumption of bread alone may support the introduction of a bakery facility in the study region. The facility could be established either at Brochet or Lac Brochet given adequate power, winter road transport of raw materials and proper storage facilities for bulk shipments of pre-mixed doughs, etc. Bun sales tend to relate to bread sales by an average volume of 1 dozen buns for every 10 loaves of bread. This would imply the sale of 150 dozen buns per week at present and up to 400 dozen buns per week in the future. Pastries and other items could average as much as 30% of bread and bun volume.

A study region bakery could therefore potentially experience the following average sales:

Present

Bread: 1,500 loaves/week x 52 @ $1.09 =	$ 85,020
Buns: 150 dozen/week x 52 @ $1.09 =	8,500
Pastry: 30% of Bread & Buns	28,055
Total Potential Sales	$121,575

Future

Bread: 4,000 loaves/week x 52 @ $1.09 =	$226,720
Buns: 400 dozen/week x 52 @ $1.09 =	22,670
Pastry: 30% of Bread & Buns	74,815
	$324,205

The above sales projections assume that freshness factor/ local production would capture the market and that pricing would be similar to current levels. Arrangements with local store outlets to carry local bakery products would enhance chances of successful introduction.

Project costs were estimated as follows:

Basic Building 1,100 sq.ft. @ $70/sq.ft.	$ 77,000
Appropriate Warehouse Storage 750 sq.ft.@ 20	15,000
Bakery Equipment incl. 120,000 btu/hr oven, proofer, mixers, etc.	50,000
Vehicle	12,000
Raw Materials for Year	50,000
Cash	20,000
Total Bakery Cost	$224,000

The bakery can only be considered if the project were to have adequate energy at reasonable cost, adequate water supply, sewage treatment and an appropriate storage structure.

Break Even Analysis

Principal & Interest $90,000 @ 12% over 15 years	$ 12,780
Fixed Costs, Building Operation, Utilities, etc.	20,000
	$ 32,780

Assume Variable Cost of 75%

Required Break-Even Volume $\frac{\$32,780}{(100\% - 75\%)}$ = $131,120

It is apparent that the proposed bakery could almost break-even immediately if suitable infrastructure and energy amenities were available. Grants and equity amounting to $134,000 or 60% of project costs would be required for the project to break even. Three to four (3-4) permanent jobs could be generated by the potential bakery.

Housing Repair/Renovation:

The projected increase in population, related housing and other construction should create demand for general building repair and maintenance services. A properly trained individual could probably successfully market his services to area residents and would require a lighted, heated, serviced building/workshop of approximately 750 square feet. Energy will be required to operate power tools, motors, etc. One (1) shop could be located in each community.

Electrical Installation/Appliance Repair:

The projected increase in population and related construction should similarly create demand for electrical system installation, repair and appliance repair services. A properly trained individual would require a building/workshop of approximately 750 square feet. Energy will be required to operate power tools, motors, etc. One (1) shop should be located in each community.

Laundromat:

Some interest has been expressed in regards to the installation of central laundromat facilities in both communities. If ample power and suitable infrastructure become available, and most families purchase their own washer/dryer equipment as indicated in the survey, the demand for community laundromat facilities will be insignificant. If most families acquire their own laundry facilities, the laundromat as proposed would not be feasible. This development alternative is presented as an option only for possible future considerations.

As Brochet experiences anticipated population growth, the area could eventually contain 270 family units. If a significant portion of these families, say 50 - 60%, do not acquire their own laundry facilities, the Brochet laundromat could be comprised of 4 - 6 washers and 4 - 6 dryers of the large commercial variety. Associated energy requirements would include a heated, lighted 1,000 sq. ft. building; 4 hot water heaters; and sufficient power to operate the dryers and washers.

Lac Brochet could eventually contain 160 family units. In order to achieve a break-even level, approximately 130 Lac Brochet families or 80% of the family groups would have to utilize the laundromat consistently.

The associated capital and operating costs are estimated as follows:

Basic Building 1,000 sq.ft. @ $70	$ 70,000
Machines, Equipment, etc.	30,000
Hook-Ups, etc.	10,000
Cash & Inventory (Soaps, etc.)	10,000
Total Estimated Laundry Cost	$120,000

Potential Revenue:

Washers - 130 families x 9 loads/week @ 75¢/load x 52 weeks	$45,630
Dryers - 130 families x 4.5 loads/week @ 30¢/load x 52 weeks	9,125
	$54,755

Applied Costs:

Principal & Interest on $22,000 @ 12% over 10 years	$ 3,745
Labour - 1 man year	10,000
Utilities	25,000
Overhead	10,000
Total Costs	$48,745
Estimated Profit	$6,010

Assuming sufficient market demand and utilization, a laundromat in each community could potentially generate two permanent employment opportunities in the study region. Grant and equity amounting to $98,000 or 82% of project costs would be required. One (1) job per laundromat could potentially be created.

Adequate infrastructure to effectively treat effluent is also a critical pre-requisite to development.

Tourism Potential:

A non-native individual presently owns and operates a fly-in lodge facility on Reindeer Lake. The lodge hires Brochet natives to act as guides. Reindeer Lake is a major fishery resource and should have little difficulty in supporting an additional tourism facility which could be owned and operated by the Barren Lands Band. The two (2) lodges would be competing directly for the large U.S. sport fishing market. Specific market analysis would be required to determine feasibility.

It is important to note, however, that the successful operation of a lodge requires careful management, diligent cost control and an effective promotion campaign. Available fishery or energy resources are no guarantee of profitable operations. The Barren Lands Band will require careful consideration and adequately trained personnel to enter the lodge market. Finally, high risk is always associated with attempting to attract a far removed market to an isolated area. In recent years many well run lodges have experienced losses due to poor economic conditions, inflation, etc. Any lodge facility introduced into the study region would be susceptible to these conditions.

Capital costs of a lodge facility could approach the following:

Basic Building - 20 patrons @ 250 sq. ft. @ $40/sq. ft.	$200,000
Furnishings, Boats, Motors, etc.	50,000
Kitchen Equipment including grill, stove, deep fryer, refrigerator, freezer, etc.	20,000
Stock and Working Capital	50,000
	$320,000

The building would require light, energy for all kitchen equipment, motors, etc. and some electric baseboard heating to provide auxillary heat during the cold days of May or September.

Principal & Interest on $128,000 @ 12% over 15 years	$ 18,130
Fixed Costs & Overhead	25,000
	$ 43,130

Assuming 70% Variable Cost:

$$\text{Required Break-Even Volume} = \frac{\$43,130}{(100\% - 70\%)} = \$143,760$$

Allowing for an average five (5) day trip at a lodge price of $1,200 per patron not including airfare, the lodge would have to experience patronage by 120 persons per year to break even. A significant marketing effort would be required to achieve such sustaining sales as some of the most well known lodges in Manitoba did not receive 120 patrons in 1983.

Grant and equity amounting to $192,000 or 60% of project costs would be required.

While the proposed lodge could create 10 - 15 part time jobs, this venture should be considered risky at best.

5.

PRESENT ENERGY USAGE AND LOAD GROWTH ANALYSIS

5. PRESENT ENERGY USAGE AND LOAD GROWTH ANALYSIS

5.1 Present Energy Use

Site surveys were conducted for all institutional and community services buildings in both communities. Drawings, energy use and energy cost information was obtained for most of the buildings. Sample houses in the Native and Metis community in Brochet and Native community in Lac Brochet were inspected. The information gathered on site was used to supplement the community base data survey presented in earlier sections of this report.

The contribution to the peak electrical demand (kw) was determined for each building by estimating what typical electrical loads in each building would be in operation during the Manitoba Hydro 82/83 recorded peak of 210 kw in Brochet and 66 kw in Lac Brochet.

Accompanying Tables 5-1 and 5-2 summarize the present estimated annual electrical and heating fuel requirements for both communities.

Appendix A and B of this report contain the reference notes pertaining to the present energy useage depicted on Tables 5-1 and 5-2.

Estimated Electrical & Heating Fuel Requirements (1982/83) Brochet

Table 5-1

	Electrical		Wood	Heating	
	kW	mWh	(Cords)	Oil (L)	Propane (kg)
Treaty					
Housing [1]	50	216	550		
Other Buildings [2]					
Band Office, Pool Hall, Community Hall, Post Office	2	10		4 100	
Other Facilities [3]					
Pump House	8	40		4 000	
Water Distribution System	1	7			
Metis [4]					
Housing	41	174	451		
Non-Native [5]					
Fathers House	2	9		6 800	90
Sisters House	1	4			
Church		1	8		
School and Teacherages	72	232		215 180	2 070
Nursing Station (New and Old) Plus Garage	10	80		34 777	
Hudson Bay Store and Houses	14	84		21 302	
RCMP Trailer and Cell Trailer	1	7		9 305	30
MTS Building	4	8			
Airport and Garage	4	14		8 000	
Total	210	886	1 009	303 464	2 190
Actual (Recorded by Manitoba Hydro)	210	834			

Estimated Electrical & Heating Fuel Requirements
(1982/83) Lac Brochet Table 5-2

	Electrical			Heating	
	Wood	Oil	Propane		
	kW	mWh	(Cords)	(L)	(kg)
Treaty [1]					
Housing	30	130	495		
Other Buildings [2]					
Band Office, Pool Hall, Community Hall, Fathers House	2	10	10		
Church	1	1	10		
School and Teacherages	14	40		50 790	1 769
Non-Native [3]					
Nursing Station and Workshop	4	34		13 548	1 575
General Store and Residence	7	20	20		
RCMP Trailer	1	4		2 000	30
MTS Building	4	14			
Airport Terminal and Garages	3	16	___	10 592	___
Estimated Electrical kW/mWh	66	269	535	76 930	3 374
Actual (Recorded by Manitoba Hydro)	66	284			

5.2 Present Energy Costs

The present cost of energy incurred by study area members is discussed below.

5.2.1 Electrical

There are basically two electrical rates being applied by Manitoba Hydro in these communities. The rates below were in effect during study completion:

1) Full Cost Diesel Rate (for customers with no capacity limitations)

Brochet: Contribution paid 23.7¢/kwh + $12.05/month Service Charge
No contribution paid 23.8¢/kwh + $12.05/month Service Charge

Lac Brochet: Contribution paid 47.1¢/kwh + $12.05/month Service Charge

"Contribution Paid Rate" is the rate customers pay if they had paid an initial lump sum to receive service.

"No Contribution Paid Rate" is the rate customers pay if they have not paid an initial lump sum to receive service. This rate is no longer available and a contribution is required from every new service.

2) Residential Rate - Diesel Generation Community (subject to service capacity limitation of a dual 15 amp service)

2) con't

Brochet and Lac Brochet:

$8.75 service charge
5.47¢/kwh first 250 kwh
2.77¢/kwh balance of kwh

In addition, a 6% provincial sales tax is charged on the monthly total.

Manitoba Hydro was contemplating a rate increase of 7.9% to take effect after April 1, 1984.

The Manitoba Hydro total operating cost in the 1982/83 period was (See Appendix A and B).

Brochet	25.7¢/kwh
Lac Brochet	56.9¢/kwh

This cost includes such items as general maintenance, labour, parts, travelling, contract labour, fuel and lube oil, fuel haulage administration, administration, overhead, depreciation and interest.

According to Manitoba Hydro's operating cost and revenue data, electrical generation in the communities experienced the following deficit in 1982/83:

	Revenue	Cost	Deficit
Brochet	$175,921	$214,523	$(38,602)
Lac Brochet	155,874	161,554	(5,680)
Total	$331,795	$376,077	$(44,282)

5.2.1 Electrical (con't)

The estimated cost breakdown for Treaty, Metis and Non-Native users, using Manitoba Hydro published rates and billing information forwarded by local institutions is summarized in Table 5-3 on page 72.

5.2.2 Firewood/Gasoline

According to the housing survey, some people buy their cord wood by the "skidoo" or boat load and others gather their own wood. Home heating wood procurement costs therefore include the cost of gasoline used in the boats/skidoo machines which actually harvest the wood. The community survey provided indications of the amount of gasoline consumed by those who gathered their own wood. The cost of hiring someone to gather wood includes gasoline, machine utilization and owner/operator time. The actual cost of gasoline associated with hiring someone to gather wood was not determined during this study. However, it was assumed that the average volume of gasoline consumed by those households which gathered their own wood was similar to those households which paid for wood gathering.

Brochet - Treaty:

The community survey found that 68% of the Treaty people collect their own wood and the remainder pay $40 per skidoo or boat load for someone else to collect it.

Present Electrical Consumption and Cost (1982-83) Table 5-3

Brochet	Electrical Consumption (kWh/a)	(¢/kWh)	Total $ Cost Including 6% P.S.T. and Service Charge
Treaty:			
Housing	216,350	7.8[1]	18,200
Other Facilities	47,000	23.7	10,600
Total Treaty			28,800
Metis Total	174,209	7.5[1]	13,100
Non-Native:			
Housing	13,675	7.5[1]	1,026
School & Teacherage	232,236	34.9	81,149
Nursing Station	79,970	32.4	25,936
Hudson Bay Store	83,500	35	29,226
RCMP Trailers	6,654	35.5	2,364
MTS Building	7,765	34	2,640
Airport	13,714	35	4,800
Total Non-Native			147,140
Lac Brochet			
Treaty:			
Housing	130,400	8.6[1]	11,180
Full Cost Customers			
School & Teacherage)			
Nursing Station)			
General Store)	183,000	78.5	$143,655
RCMP Trailer)			
MTS Building)			
Airport)			

Note 1: Effective housing rate from Housing Survey

Note 2: These estimates are indications of the cost breakdowns described on page 70. There are discrepancies between table 5-3 and the data presented on page 70 due to the application of Provincial Sales Tax which is not reflected on page 70 data.

	Cost/Household	Number of Households	Total Cost
Wood Hauling	$663 (716 L of gasoline)	50	$33,150
Those who buy wood @ $40/load	$1,800 (45 loads/ year & 716 L of gasoline)	16	28,800
Total Cost			$61,950

Person hours to collect wood 2.75 hours (45 loads/year) 50 = 6,188 hours. Average cord wood consumption per household has been estimated at 11 to 18 cords per year.

Brochet - Metis:

Since most respondents collect their own wood and since the average cost for gasoline per household is $629, the total Metis cost to collect wood is 41 (629) = $25,800. The total person hours required to collect wood is (132 hours/household) (41) = 5,514 hours for 11 - 18 cords per annum.

Lac Brochet:

Since the number of loads of cord wood was not reported in the survey for Lac Brochet, it is assumed to be similar to the quantity for Brochet Treaty, ie: 45 loads or 11 - 18 cords per annum. However, about 22 of the 45 households collect their own wood while the remainder purchase their wood for $40/load.

	Cost/Household	Number of Households	Total Cost
Wood Hauling	$1,060 (961 L of gasoline)	45	$47,700
Those who buy wood @ $40/load	$1,800 (45 loads/ year & 916 L of gasoline)	23	41,400
Total Cost			$89,100

Person hours to collect wood 1.75 hours (45 loads/year) x 45 households = 3,544 hours.

Total Both Communities:

	Dollar Value	Hours
Treaty	$151,050	9,732
Metis	25,800	5,412
Total	$176,800	15,144

5.2.3 Oil

Oil for space heating and diesel generator fuel is shipped into Brochet either by winter road or by air. Costs for institutional and Band buildings varied due to the shipping methods, method of containment (bladder or barrels), carry over of oil storage from one year to the next, and bulk purchases.

	Stated Oil Costs ¢/Litre	
	Brochet	Lac Brochet
Nursing Stations	59	83
Frontier School Division	42.9	
Lac Brochet School		
Hudson Bay Store	58	81
RCMP Trailers	42.3	45
Band Office	58	
Airports	50.8	69.3
Average	51.8	67.5

Total Estimated Oil Cost

Table 5-4

Brochet	Oil Consumption (litre)	(¢/litre)	$ 1982/83 Cost Including Transportation
Treaty	4,100	58	2,378
Non-Native:			
Housing	6,800	51.8	3,522
School & Teacherage	215,180	42.9	91,235
Nursing Station	34,777	59	20,530
Hudson Bay Store & Houses	21,302	58	12,355
RCMP Trailers	9,305	42.3	3,939
Airport	8,000	50.8	4,065
Total Brochet	295,364		135,646
Lac Brochet			
Treaty:			
School & Teacherage	50,790	64	32,500
Non-Native:			
Nursing Station	13,548	83	11,227
RCMP Trailer	2,000	45	900
Airport	10,592	69.3	7,341
Total Lac Brochet	76,930		51,968

Diesel fuel cost in each community is not presented with oil cost as diesel fuel cost is reflected in diesel generated electrical cost data.

5.2.4 Propane

Propane is used mainly for cooking and domestic hot water heating in both communities and is usually shipped by air in 45 kg cylinders.

Total Estimated Propane Cost

Table 5-5

Brochet	Propane Consumption (kg)	($/kg)	$ 1982/83 Cost Including Transportation
Non-Native:			
Housing	90	0.65	59
School & Teacherage	2,070	0.65	1,355
RCMP Trailers	30	0.65	20
	2,190		2,434
Lac Brochet			
Treaty:			
School & Teacherage	1,769	2.20	3,900
Non-Native:			
Nursing Station	1,575	2.20	3,480
RCMP Trailer	30	2.20	66
	1,605		3,546

5.2.5 Present Energy Cost Summary

The foregoing present energy costs are summarized below:

Total Energy Costs $ (1982/83) Both Communities — Table 5-6

Brochet	Electrical	Wood/ Gasoline	Oil	Propane	Total Cost Estimated
Treaty	$ 28,800	$ 61,950	$ 2,378	n/a	$ 93,128
Metis	13,100	25,800	n/a	n/a	38,900
Non-Native	147,140	n/a	135,646	1,434	285,220
Lac Brochet					
Treaty Housing	11,180	89,100	32,500	3,900	136,680
Full Cost Rate	143,655	n/a	19,468	3,546	166,669
Totals	343,875	176,850	189,992	9,880	720,597

Average Cost/Unit of Energy (Brochet - Lac Brochet)

Electricity - Consumer:
- Full Diesel Rate 23.7¢ - 47.1¢/kwh & service charge
- Residential 27.7¢ - 54.7¢/kwh & service charge

Electricity - Hydro:
- Total Operating Cost 25.7¢ - 56.9¢/kwh - operations experience deficit

Gasoline/Wood:
- Average Price 11 cords/house x 136 houses = 1,496 cords
- $176,850/1,496 = $118/cord
- Gasoline Average Price 93¢ - $1.10/litre
- Gasoline Average Consumption 716 (L) - 961 (L) per household

Oil:
- Delivered to Area 51.8¢ - 67.5¢/litre

Propane:
- Recharged cylinders delivered to area 65¢ - $2.20/kg.

The price ranges represent different rates for each community, Lac Brochet experiencing the higher charge, and were utilized as a basis for energy cost projections.

5.3 Energy Conservation Potential

Heat Recovery From Diesel Plant

Presently, heat from the diesel generators is continuously vented to the outdoors. This waste heat could be utilized year round to heat the school and teacherages which are dependent on fuel oil for heating purposes.

According to Manitoba Hydro, the heat from the generators is composed of 30% electrical power, 30% stack losses, 30% jacket water and 10% engine radiation loss. It is estimated that 60% to 70% of the jacket loss is economically recoverable.

Based upon the highest measured hydro peak of 210 kw and a 65% recovery rate, the total annual energy available is 360,000 kwh (210 x 30 x 65% x 8,760 hrs/year). If this energy is used to supplement the 26 oil furnaces at the school and teacherages over a 10 month period, an estimated 30,000 L ($15,000 in 1984 $) of fuel oil could be saved for the school and teacherages. Alternatively, the recovery heat could be used to supplement heating for other nearby developments.

Manitoba Hydro have quoted an approximate cost of $180,000 to provide a supply and return pipe from all the generators to the fenced boundary around their building. This would include all required pumps and controls at the station. The cost to run a buried insulated supply and return pipe to the school and

teacherages, retrofit water to air heat recovery coils in each furnace, install the circulation pumps and glycol would cost about $220,000. The total project cost would then approach $400,000.

The system would be designed to handle the total capacity of the generator plant such that when electrical consumption doubles, $30,000 of the present school heating costs would be supplied by the diesel plant heat recovery system.

The laundromat developments considered for each community could benefit from the above heat recovery system from an energy viewpoint. A centralized laundromat facility utilizing heat recovery from the generators, would probably be more economical to operate than individual units. Specific study would be required to pursue this possibility.

Air Leakage Reduction and General Energy Conservation Recommendations

Existing housing and other buildings in both Brochet and Lac Brochet are judged to have a high degree of air leakage around door and window frames, attic hatch, baseboards and other cracks. Estimated savings could approach 30% of heating costs if a good sealing program is performed on these buildings.

Energy savings would be in cord wood and oil consumption. Annual savings estimates for both communities are as follows:

	Cord Wood $ Savings	Fuel Oil $ Savings	
Brochet:			
Treaty Housing	18,000	700	
Metis Housing	7,700		
Nursing Station		4,000	
Hudson Bay Store		3,500	
RCMP Trailer		1,200	
Airport Buildings		1,200	
			$36,300
Lac Brochet:			
Treaty Housing	26,000		
School & Teacherages		10,000	
Nursing Station		3,400	
General Store		1,500	
RCMP Trailer		300	
Airport Buildings		2,100	
			$43,300
Total Projected Savings (1983 $'s) per year			$79,600

The total cost to perform this sealing program for both communities was estimated by a Winnipeg contractor specializing in weathersealing and approximates $125,000 including all materials, travel and accommodation costs.

The school and teacherages in Brochet have not been included in this weathersealing recommendation since they are already planned to be weathersealed under a separate energy conservation program.

The following items should also be improved:

- insulate basement walls of Fathers house and Church in Brochet. Projected savings $1,000/year estimated cost $3,000.
- add a second window to the single pane windows on the Brochet Air Terminal Building.
- add vapour barrier to the Lac Brochet Nursing Station insulated crawlspace wall.
- replace all regular fluorescent lamps and ballasts in the Lac Brochet School classrooms, Brochet and Lac Brochet Nursing Stations, and general stores, etc., with low wattage fluorescent lamps and high efficiency ballasts. For the estimated 2,000 lamps the estimated cost is $6,000 for a savings of about $7,000/year.
- replace existing thermostats in Lac Brochet School classrooms and other buildings with low use, with temperature setback thermostats and set temperature back about 15°F for 128 hours/week. This will save about 15% of the annual oil consumption of the school classroom or about $6,000/year for a cost of 7 thermostats approaching $1,000.
- improve efficiency of oil furnaces in all buildings by installing flame retention head burners, and changing fan thermostat settings to 100°F on, 80° off. A report E1-79-8, "Efficient Residential Oil Heating Systems", prepared by the Canadian Combustion Research Laboratory, shows field results of 20% fuel savings by retrofitting a retention head on the oil furnace. The nozzle size should also be reduced at least one standard size when the retention head is retrofitted and perhaps even more if the furnace is oversized. However, it

should be noted that since flame temperatures are higher with this system, there could be problems with the combustion chamber. If the combustion chamber is made of stainless steel or firebrick, it must be fitted with a ceramic fibre fitting. If the chamber is not already lined with this ceramic, the higher temperatures could lead to burn-out of the combustion chamber. This, as well as furnace efficiency, should be checked prior to considering this retrofit item.

If all oil furnaces could be retrofitted, the potential energy saving is about $20,000/year (excluding the oil furnaces in the Brochet school and teacherages as they are likely to be addressed under a separate energy conservation program).

The cost to add the retention head and change nozzle size (if furnace linings do not have to be changed), for the estimated 40 oil furnaces in total for Brochet and Lac Brochet (excluding Brochet School and teacherages), is estimated at $12,000 including travel and accommodations.

- Energy conservation items for the school in Brochet include: closing open crawlspace vents, weatherstripping, temperature setback, fresh air control, furnace control modification, lighting conversion. These retrofit items have not been costed for this study as they are addressed under a separate energy conservation program "Enerschool". The savings and cost for the school under this program are $41,500 and $86,500 respectively.

5.3 con't

Summary of Energy Conservation Potential

	Projected Savings ($/yr)	Estimated Cost ($)	Simple Payback (years)
Air Leakage Reduction	$79,600	$125,000	1.6
Insulation	3,500	9,000	2.6
Lighting Conversion	7,000	6,000	.85
Temperature Setback	6,000	1,000	.17
Oil Furnace Efficiency Improvement	20,000	12,000	
TOTALS	$98,100	$153,000	

5.4 Load Growth Forecasts

The electrical load growth (kw and mwh) for each community is projected from 1983 to 2008 for the following cases:

1) Low Load Forecast - The present 15 A, 240 V service capacity limitation for residential is maintained.

2) Intermediate Load Forecast - The residential sector installs 100 or 125 A breakers, uses new and larger appliances but electric heat is not allowed.

3) High Load Forecast - Present services install 125 A or larger breakers and services upgraded to handle electric heating.

Study area electrical requirements are expected to increase due to additional housing for the increasing population, new Social/Support Facilities (Elderly Care Home and Community Complex) and probable expansion for the Schools, Nursing Stations, General stores and Airport Terminals. Other future economic developments are not included in these load forecasts.

5.4.1 Low Load Forecast

Housing

The following table presents the expected increase in housing in the study area over the next 25 years. This information is based upon the Community Base Data - Housing Survey presented earlier in this report.

Period	Brochet Treaty	Metis	Lac Brochet Treaty	Cumulative Total
Existing 82/83 Housing Stock	50	41	45	136
1983/88	70	56	70	196
1988/93	90	61	90	241
1993/98	110	71	110	291
1998/03	135	86	135	356
2003/08	160	110	160	430

As new houses are constructed, they are assumed to be connected to Hydro under existing conditions of capacity limitations. The 4,327 kwh consumption identified in the Community Base Data - Housing Survey and an estimated 1 kw per house is used in calculating the expected electrical requirements illustrated on Tables 5-6 and 5-7.

Since the diesel plant in Lac Brochet was recently put into service in 81/82, it is estimated that only about 30 of the 45 Treaty houses are serviced by Manitoba Hydro. However, by 1988, the remaining 15 houses and the projected 25 new houses are all assumed to be connected to Manitoba Hydro and a similar electrical requirement of 4,327 kwh and 1 kw per house is used in the projections.

Other Buildings and Facilities

The pump house in Brochet will have an increased consumption of about 10 mwh every five years due to a population demand increases. A new pumphouse with a standpipe distribution system is scheduled for construction in Lac Brochet in 84/85- with associated electrical requirement approximating 9 kw and 30 mwh/year. Thereafter, this requirement will increase at the rate of about 10 mwh every five years.

Other buildings (Band Office, Pool Hall, Community Hall, etc.) are assumed to remain at the existing level of electrical consumption until the year 1998 when a new 6,000 sq. ft. Community Complex in Brochet and a 4,000 sq.ft. complex in Lac Brochet could replace them. For purposes of this forecast, no increase in electrical requirement is anticipated.

No change in requirement is expected for the Father's house, Sister's house or Church in both communities.

School and Teacherages

The School and Teacherages in Brochet are assumed to double in 1998 to meet educational requirements. This yields a total requirement of 144 kw and 464 mwh in 1998.

The School in Lac Brochet is presently reported to be at its capacity and a new facility is planned in the near future. Assuming the School and Teacherages double in size by 1988 and are increased by a further 50% in the year 1998, the expected electrical requirement would be 28 kw and 80 mwh in 1988 and 42 kw and 120 kwh in 1998.

Nursing Stations and Airport Terminal

Both Nursing Stations and Airport Terminals at Brochet and Lac Brochet are assumed to double in size and electrical requirements in 1998 in order to meet increased population demands.

General Stores

The Hudson Bay Store in Brochet is assumed to increase by 3,000 sq.ft. to a total of 7,700 sq.ft. and will have a proportional increase in electrical requirements. The store in Lac Brochet is assumed to increase by 1,000 sq.ft. to a total of 3,000 sq.ft. and will also have a proportional increase in electrical requirements.

RCMP Trailer and MTS Building

No change in electrical requirements is expected for these facilities.

Elderly Care Home

If a 9,000 sq.ft. Elderly Care Home in Brochet and 5,000 sq.ft. facility in Lac Brochet are constructed in 1998 then approximately half of the 20 kw lighting load in Brochet and

10 kw load in Lac Brochet will contribute to peak kw electrical requirements. Assuming lights are in use 10 hours per day and 365 days/year, the annual consumption is calculated to be 40 mwh and 20 mwh for Brochet and Lac Brochet respectively.

Low Load Electrical Demand Forecast **Table 5-7**
Brochet - kw/mwh per year

	Present 82/83	1988	1993	1998	2003	2008
Treaty:						
Housing	50/216	70/302	90/389	110/475	135/583	160/691
Other Buildings[1]	2/10	2/10	2/10			
Other Facilities[2]	9/47	9/47	9/57	9/67	9/77	9/87
Metis:						
Housing	41/177	56/242	61/264	71/307	86/372	111/480
Non-Native:						
Fathers House)						
Sisters House)	3/14	3/14	3/14	3/14	3/14	3/14
Church)						
School & Teacherage[3]	72/232	72/232	72/232	144/464	144/464	144/464
Nursing Station[3]	10/80	10/80	10/80	20/160	20/160	20/160
Hudson Bay Store and Residences	14/84	14/84	14/84	21/126	21/126	21/126
RCMP Trailers	1/7	1/7	1/7	1/7	1/7	1/7
MTS Building	4/8	4/8	4/8	4/8	4/8	4/8
Airport Terminal and Garage	4/14	4/14	4/14	8/28	8/28	8/28
Social/Support Facilities:						
Elderly Care Home[4]				10/40	10/40	10/40
Community Complex[1]				4/20	4/20	4/20
Totals	210/886	245/1040	270/1159	405/1716	445/1899	495/2125

Notes:

1. Assumes other buildings (Band Office, Pool Hall, Community Hall and Post Office) replaced with a new 6,000 sq.ft. community complex in 1998.
2. Pump House and water distribution system.
3. Assumes size of school, teacherage, nursing station, airport terminal, doubles in 1998.
4. Assumes a 9,000 sq.ft. Elderly Care Home added in 1998.

Low Load Electrical Demand Forecast **Table 5-8**
Lac Brochet - kw/mwh per year

	Present 82/83	1988	1993	1998	2003	2008
Treaty:						
Housing[1]	30/130	70/302	90/398	110/475	135/583	160/691
Other Buildings:[2]						
Band Office, Pool Hall, Community Hall	2/10	2/10	2/10			
Father's House) Church)	1/2	1/2	1/2	1/2	1/2	1/2
School & Teacherage[3]	14/40	28/80	28/80	42/120	42/120	42/120
Pump House[4]		9/30	9/40	9/50	9/60	9/70
Non-Native:						
Nursing Station and Workshop[5]	4/34	4/34	4/34	8/68	8/68	8/68
General Store and Residence[6]	7/20	7/20	7/20	10/28	10/28	10/28
RCMP Trailer	1/4	1/4	1/4	1/4	1/4	1/4
MTS Building	4/14	4/14	4/14	4/14	4/14	4/14
Airport Terminal and Garages[5]	3/16	3/16	3/16	6/32	6/32	6/32
Social/Support Facilities:						
Elderly Care Home[7]				5/20	5/20	5/20
Community Complex[1]				2/10	2/10	2/10
Totals	66/270	129/512	149/599	196/803	221/931	248/1059

Notes:

1. Assumes only 30 houses are connected to the electrical system. Remainder of 45 houses and new houses assumed connected in 1988.
2. Other Buildings (Band Office, Pool Hall and Community Hall) assumed replaced with new 4,000 sq.ft. Community Complex in 1998.
3. Assumes school and teacherage double in size in 1988 and increases a further 50% by 1998.
4. Assumes pump house planned for 84/85 in operation.
5. Assumes nursing station and airport buildings double in size by 1998.
6. Assumes an additional 1,000 sq.ft. is added to the general store by 1998.
7. Assumes a 5,000 sq.ft. Elderly Care home is added by 1998.

Oil, wood/gasoline and propane energy requirements will also increase according to population and resultant services increases as low load electrical maintenance will not displace any of these other energy sources.

Projected Oil, Wood/Gasoline, Propane Use to Year 2008
Assuming Low Load Electricity Resource Maintained Table 5-9

	Present 82/83	1988	1993	1998	2003	2008
Oil:						
Brochet (L)	303,464	303,464	303,464	436,800	436,800	436,800
Lac Brochet (L)	76,910	122,120	124,120	190,000	192,000	194,000
Total (L)	380,374	425,584	427,584	626,800	628,800	630,800
Wood/Gasoline:						
Brochet (Cords)	1,001	1,386	1,661	1,991	2,431	2,970
Lac Brochet (Cords)	495	770	990	1,210	1,485	1,760
Total	1,496	2,156	2,651	3,201	3,916	4,730
Gasoline Required:						
Brochet (L)	65,156	90,216	108,118	129,596	158,236	193,320
Lac Brochet (L)	43,245	67,270	86,490	105,710	129,735	153,760
Total (L)	108,401	157,486	194,606	235,306	287,971	347,080
Propane:						
Brochet (kg)	2,190	2,190	2,190	4,630	4,630	4,630
Lac Brochet (kg)	3,374	4,605	4,605	6,340	6,340	6,340
Total (kg)	5,564	6,795	6,795	10,970	10,970	10,970

5.4.2 Intermediate Load Forecast (No Electric Heat Allowed)

If the 15 A at 240 VAC service capacity limitation is removed, it is expected that the communities would improve their standard of living by using new and larger appliances and construct social and support facilities as discussed in the community base data.

Tables 5-10 and 5-11 present a summary of the expected electrical requirements for both communities between the years 1983 to 2008 if modern household appliances and new social/support facilities are used. Appendix C contains a discussion of intermediate load forecast assumptions.

The "Expected Electrical Requirement" is the estimated peak kw and mwh of household lighting and appliances. A diversity factor of 30% of the installed capacity is assumed to contribute to this peak.

Consumption is expressed in mwh and is the average annual electrical energy consumption. Winter periods will have a slightly higher mwh than summer because of a reduction in lighting and outdoor cooking in summer.

Intermediate Load Forecast - Brochet
(No Electric Heat Allowed)

Table 5-10

	Present 1983	1988	1993	1998	2003	2008
Treaty:						
Housing	50/216	214/715	378/1215	462/1485	567/1823	672/2160
Other Buildings[1]	2/10	10/10	10/10			
Other Facilities	9/47	21/127	21/137	21/147	21/157	21/167
Metis:						
Housing	41/177	189/756	256/824	298/959	361/1161	466/1500
Non-Native:						
Fathers and Sisters Church	3/14	10/20	10/20	10/20	10/20	10/20
School & Teacherages	72/232	102/312	102/312	204/624	204/620	204/624
Nursing Station	10/80	12/87	12/87	24/174	24/174	24/174
Hudson Bay Store and Houses	14/84	14/84	14/84	21/126	21/126	21/126
RCMP Trailers	1/7	4/10	4/10	4/10	4/10	4/10
MTS Building	4/8	5/8	5/8	5/8	5/8	5/8
Airport and Garage	4/14	4/14	4/14	8/28	8/28	8/28
New Social/Support Facilities:						
Elderly Care Home				20/120	20/120	20/120
Community Complex				15/20	15/20	15/20
Warehouse				5/36	5/36	5/36
Totals	210/886	585/2143	816/2721	1097/3757	1265/4307	1475/5000

Intermediate Load Forecast - Lac Brochet
(No Electric Heat Allowed)

Table 5-11

	Present 1983	1988	1993	1998	2003	2008
Treaty:						
Housing	30/130	214/715	378/1215	462/1485	567/1823	672/2160
Other Buildings:						
Band Office, Pool Hall, Community Hall	2/10	10/13	10/13			
Fathers House Church	1/2	1/2	1/2	1/2	1/2	1/2
Other Facilities:						
Pump House Sewage System		21/70	21/80	21/90	21/100	21/110
School & Teacherages	14/40	29/80	60/160	60/160	90/240	90/240
Non-Native:						
Nursing Station and Workshop	4/34	9/45	9/45	18/90	18/90	18/90
General Store and Residence	7/20	7/20	7/20	10/28	10/28	10/28
RCMP Trailers	1/4	4/10	4/10	4/10	4/10	4/10
MTS Building	4/14	4/14	4/14	4/14	4/14	4/14
Airport Terminal and Garage	3/16	3/16	3/16	6/32	6/32	6/32
New Social/Support Facilities:						
Elderly Care Home[3]				12/70	12/70	12/70
Community Complex[1]				10/13	10/13	10/12
Warehouse[3]				4/24	4/24	4/24
Totals	66/270	302/985	447/1559	612/2016	747/2946	852/2793

Oil and wood/gasoline energy requirements will also increase according to population and increases in resultant services as intermediate load electrical service will not significantly displace these other energy sources. Propane would no longer be required as electricity would be utilized for major appliances, water heating, etc.

Projected Oil, Wood/Gasoline, Propane Use to Year 2008 Assuming Low Load Electricity Resource Maintained Table 5-12

	Present 82/83	1988	1993	1998	2003	2008
Oil:						
Brochet (L)	303,464	303,464	303,464	436,800	436,800	436,800
Lac Brochet (L)	76,910	122,120	124,120	190,000	192,000	194,000
Total (L)	380,374	425,584	427,584	626,800	628,800	630,800
Wood/Gasoline:						
Brochet (Cords)	1,001	1,386	1,661	1,991	2,431	2,970
Lac Brochet (Cords)	495	770	990	1,210	1,485	1,760
Total	1,496	2,156	2,651	3,201	3,916	4,730
Gasoline Required:						
Brochet (L)	65,156	90,216	108,118	129,596	158,236	193,320
Lac Brochet (L)	43,245	67,270	86,490	105,710	129,735	153,760
Total (L)	108,401	157,486	194,606	235,306	287,971	347,080

5.4.3 High Load Capacity

According to community base data, most of the people in both communities would install electric heat if allowed and the cost was reasonable compared to wood heat. In order to estimate the expected electrical requirements (kW and mWh) for each community the following assumptions were made:

- All existing housing stock will be weathersealed to a 3/4 air change rate/hr (AC/h), but only 50% of the existing housing stock would convert. This is due to the low thermal resistance of some of the houses and the short useful remaining life of some of the existing housing stock.

- All new housing stock will convert to electric heating and be constructed with R20 walls, R40 ceiling, R20 floor and have an air change rate of 3/4 AC/h.

- All new housing will be increased to about 1,000 sq.ft. to accomodate extra appliances (freezer, hot water heater, washer and dryer, etc.).

- Due to the need for a back up heating source along with the electric heating system, it is assumed that about 20% of the total heating requirements will be supplied by a wood stove or wood furnace.

- Housing will increase at the rate presented in earlier sections of this report.

- A diversity factor of 50% has been applied to the total installed electrical heating capacity. This assumed that, on the average, only 50% of the total community installed electrical heating capacity would be energized during a peak kW condition.

- New pump house for Lac Brochet installed by 1988.

- New sewage system and lift station installed in both communities by 1988.

- New community complexes in both communities installed in 1998 to replace other buildings such as the Band Office, Pool Hall, Community Hall, etc.

- Brochet School, Teacherages, Nursing Station and Airport Terminal double in size by 1998 to meet increasing population demands.

- Store in both communities increase in size by 1998, Hudson Bay Store in Brochet by 3,000 sq.ft. and the General Store in Lac Brochet by 1,000 sq.ft.

- Elderly Care Homes, 9,000 sq.ft. in Brochet and 8,000 sq.ft. in Lac Brochet are added in 1998.

- Very little or no street lighting is added to either community.

- Brochet degree heating days 8,462 DD^{o}C and winter design temperature difference of 61^{o}C.

- High load forecast details are presented in Appendix D.

Accompanying Tables 5-13 and 5-14 summarize expected electrical requirements associated with capacity limitation removal and electric space heating installation.

High Load Forecast - Brochet

Table 5-13

	Present 1983	1988	1993	1998	2003	2008
Treaty:						
Housing	50/216	442/1420	696/2205	870/2750	1087/3438	1305/4125
Other Buildings	2/10	30/50	30/50			
Other Facilities	9/47	33/149	33/159	33/169	33/179	33/189
Metis:						
Housing	41/77	422/1460	512/1614	599/1889	729/2301	947/3340
Non-Native:						
Fathers and Sisters House	3/14	35/68	35/68	35/68	35/68	35/68
Church						
School & Teacherages	72/232	300/1000	300/1000	600/2000	600/2000	600/2000
Nursing Station	10/80	76/337	76/337	152/674	152/674	152/674
Hudson Bay Store and Houses	14/84	46/209	46/209	74/375	74/375	74/375
RCMP Trailer	1/7	8/20	8/20	8/20	8/20	8/20
MTS Building	4/8	4/8	4/8	4/8	4/8	4/8
Airport & Garage	4/14	24/94	24/94	48/188	48/188	48/188
New Social/Support Facilities:						
Elderly Care Home				60/270	60/270	60/270
Community Complex				40/70	40/70	40/70
Warehouse				30/85	30/85	30/85
Totals	210/886	1420/4815	1764/5759	2553/8566	2900/9436	3336/11172

High Load Forecast - Lac Brochet Table 5-14

	Present 1983	1988	1993	1998	2003	2008
Treaty:						
Housing	30/130	492/1575	746/2355	920/2905	1138/3593	1356/4280
Other Buildings:						
Band Office, Pool Hall, Community Hall	2/10	28/75	28/75			
Fathers House Church	1/2	17/33	17/33	17/33	17/33	17/33
Other Facilities:						
Pump House Sewage System	31/103	31/113	31/123	31/133	31/143	31/153
School & Teacherages	14/40	124/390	248/780	248/780	372/1170	372/1170
Non-Native:						
Nursing Station and Workshop	4/34	24/105	24/105	48/210	48/210	48/210
General Store	7/20	22/80	22/80	27/100	27/100	27/100
RCMP Trailers	1/4	8/20	8/20	8/20	8/20	8/20
MTS Building	4/14	4/14	4/14	4/14	4/14	4/14
Airport Terminal and Garage	3/16	16/66	16/66	32/132	32/132	32/132
New Social/Support Facilities:						
Elderly Care Home				40/135	40/135	40/135
Community Complex				35/71	35/71	35/71
Warehouse				21/50	21/50	21/50
Totals	66/270	766/2471	1144/3651	1451/4583	1768/5631	1991/6368

Oil, wood/gasoline and propane energy requirements will be altered dramatically if high load electricity is available. It is assumed that heating oil would no longer be required as electric heat would be available under high load conditions. Approximately 20% of wood/gasoline projections have been allowed for as some individuals will not convert and wood/gasoline will be maintained as a back-up heating system. Propane requirements will be negligible.

Projected Wood/Gasoline Use to Year 2008
Assuming High Load Electricity Resource

Table 5-15

	Present 82/83	1988	1993	1998	2003	2008
Wood/Gasoline:						
Brochet (Cords)	200	277	332	398	486	594
Lac Brochet (Cords)	99	154	198	242	297	352
Total	299	431	530	640	783	946
Gasoline Required:						
Brochet (L)	13,030	18,045	21,623	25,920	31,647	38,664
Lac Brochet (L)	8,649	13,454	17,298	21,142	25,947	30,752
Total (L)	21,679	31,499	38,921	47,062	57,594	69,416

5.4.4 Other Economic Developments

The Community Base Data Survey indicated a number of possible future economic developments. The following is an indication of what the energy requirements of these developments might be. These energy requirements are not included in previous load projections.

Bakery

A bakery facility in Brochet consisting of a 1,100 sq.ft., heated, lighted building, and a 750 sq.ft. heated, lighted and air conditioned warehouse sized to handle 4,000 - 16 oz. loaves of bread per week would have a peak and annual electrical requirement of 50 kw and 125,000 kwh/a respectively as based upon the following:

120,000 BTU/hr oven capable of baking 150 loaves/hr., proofing cabinet with a 2 kw immersion heater, a 1.5 kw dry heater and capable of proofing 150 loaves of bread/hr.
40 hr/week operation
4 kw of hot water heating for bakery
total of 16 kw of electric heating for bakery and warehouse
2 watts/sq.ft. for lighting
2 ton air conditioner for warehouse

Laundromat

A central laundromat facility would prove viable only if study area residents did not acquire individual washers/dryers. Individual units were included in electrical load forecasts.

A laundromat in Brochet consisting of a 1,000 sq.ft. heated and lighted facility with 6 commercial washers and dryers would be the minimum size laundry to support 50% of the 270 anticipated family units. This is based on each of the 130 families doing 9 loads of laundry per week and each washer and dryer able to hold two loads.

The peak and annual electrical requirements are 100 kw and 482,000 kwh/a and are based upon the following data:

2 washer-dryer cycles per hour
100 hr/week continuous operation
28 imperial gallons per washer per hour
water inlet & outlet temp. of 2°C to 60°C respectively
52 kw of water heating
5,900 W per dryer
2 watts per sq.ft. for lighting
1/3 hp and 1/4 hp washer and dryer motors respectively
9 kw of electric heating

5.5 Alternative Energy Supply

Solar Energy

If two 4' x 10' solar air collectors are mounted on the south wall of each of the houses, the potential saving in space heating would be about 2,914 kwh per house. The cost as quoted by LPC of Canada for 136 houses would be about $276,000.

For all existing 136 houses, the saving would amount to 400,000 kwh per year. Compared to oil, wood or electricity, the monetary savings would be:

Oil: $37,000 (7.5 year payback)
(Where 1 litre of oil is equivalent to 6.5 kwh at a seasonal efficiency of 60%. Average cost of oil for both communities is about 60¢/litre)

Wood: $14,000 (19.7 year payback)
(Where 1 cord of wood is equivalent to 5,000 kwh, 65% wood stove efficiency and a $115 cost/cord)

If a new hydro electric plant or connection with Manitoba Hydro lines occurs, savings would be at a residential rate of about 3¢/kwh for a total of $15,000 (18.4 year payback).

Wind Energy

Information was requested from 6 suppliers of wind generator equipment. Due to the low average air speed in Brochet of only 13.9 kilometers per hour and existing machine capabilities, most stated performance would be poor. For example, a DAF 6400 Vertical Axis generator with an 80 ft. diameter blade rated at 522 kw at 19 m/s yields the following annual output:

Average Annual Wind Speed (Kph)	Annual Output mwh/a
32	1,374
28.6	1,094
25.1	792
21.4	502
13.8 (Brochet)	150 (est)

Note that the output drops off very dramatically as the average Brochet wind speed is approached.

Both Mr. Mark Chappel, Program Manager of the National Research Council's Wind Program, and DAF Indal (a supplier) contend that a wind speed of at least 19.2 Kph is required.

Typically, a 500 kw generator would cost about $1,500,000 installed and at an average wind speed of 13.8 Kph, could only produce about 150 mwh/a. The average cost of wind power approaches $1/kwh which greatly exceeds present electrical energy costs in the communities.

Electricity Generating From Wood Stove

A new product that will be on the market in May of 1984 is a thermovoltaic electrical producing device, "Thermovolt", which attaches to a wood burning stove and produces between 720 to 1,200 watt hours/day. At 1,200 watt h/d, this will only yield a peak watt capacity for a 50 watt light bulb. At $1,400 US per unit, this device is not economical.

6.

WOOD FUEL RESOURCE ASSESSMENT

6. WOOD FUEL RESOURCE ASSESSMENT

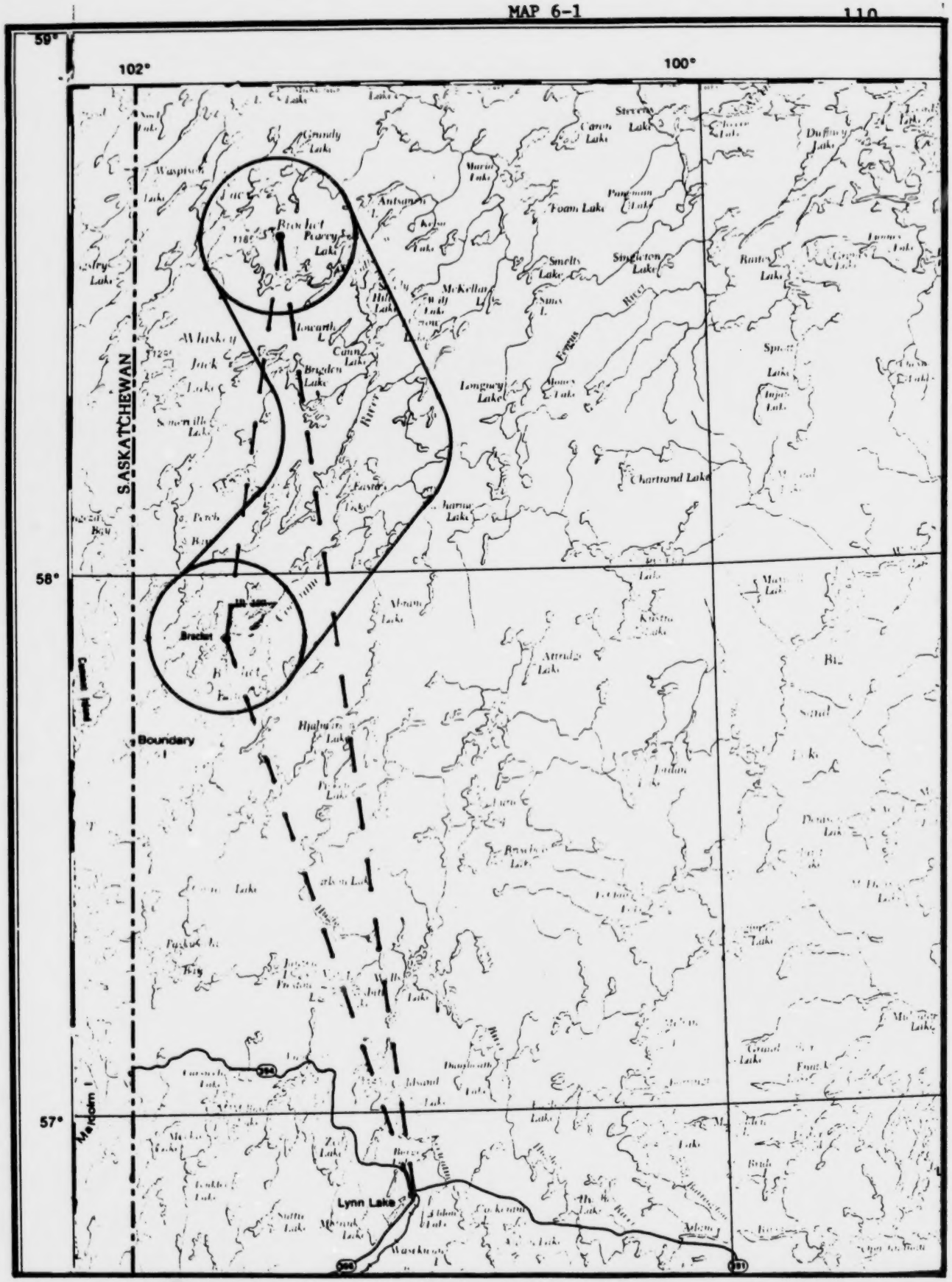
6.1 General Biophysical/Vegetation Characteristics

The Brochet - Lac Brochet Study Region is situated between, latitudes 57°45' and 58°45' North, and between longitudes 100°45' and 102° West. The area forms part of the Churchill River, Principal Drainage Division and the Cochrane River and Reindeer Lake, Major Drainage Divisions, which are further sub-divided into nineteen discrete, Watershed Units (Fedoruk 1970). For the purpose of the "Fuel Wood.....Home Heating" portion of the Energy Demonstration Study, the area examined encompasses a 16 kilometer (10 mile) radius of each community and a 16 km. wide, connecting corridor, spanning the Cochrane River (See Map 6-1).

In terms of environmental zoning the area lies entirely within the Northwestern Transition Section of the Boreal Forest Region (Rowe 1972) and the Low Subartic Ecological Region (Mills 1979). It is characterized by hummocky to undulating and drumlinoid ground moraine, consisting of deep deposits of stony, sandy loam and loamy sand, underlain by Precambrian bedrock. Strong topographic relief rises 100 meters (330 feet) above the surrounding lakes and rivers. Steep-ridged, sandy and gravelly eskers and bedrock exposures occur infrequently. Forty percent of the total area is occupied by bodies of water, 25% of the land surface is covered by deep peat bogs and fens in the lowlands and the remaining 75% is upland glacial till. Permafrost is prevalent on lower slopes and bog complexes.

The marginal tree cover is predominantly black spruce (Pincea mariana) forest with scattered stands of jack pine (Pinus banksiana) white spruce (Pincea glauca) trembling aspen (Populus tremuloides) and white birch (Betula papyrifera). Owing to the harsh climatic region with a mean annual temperature of -5.20C

(23^0F); mean annual precipitation of 430 mm. (16.9in.) and only 70 to 80 frost free days, combined with the inherent infertility of the soils, the productive capacity is greatly limited. (Environment Canada, Climatic Data, 1950-1981). The rotation age (maturity) of black spruce is 200 years, while diameters range from 10 to 20 cm. (4 to 8 in.) and heights vary from 7.5 to 12.5 meters (25 to 40 ft.). Under favourable growing conditions, sites rarely produce more than 12.5 cords (1,062 $ft.^3$/30 $m.^3$) of gross merchantable wood volume, per hectare (2.47 acres) or 5 cords per acre (425 $ft.^3$/12$m.^3$). A stacked cord of rough wood contains 85 cubic feet of solid wood or 2.407 m^3.



GEOGRAPHIC LOCATION: BROCHET - LAC BROCHET

6.2 Wildfire History

Wildfire patterns were delineated on satellite images and compilations of burned and unburned areas were tabulated.

Forest fires, caused mainly by "lightning-strikes", occurring in this part of the Province, are virtually uncontrolled by suppression crews of the Department of Natural Resources', Regional Fire Management Section. Unless loss of life is threatened and settlements or tourist resorts are in jeopardy, no fire control response can be anticipated. The study region lies 75 km. (45 mi.) north of the Forest and Fire Management Zone, administered by the Forestry Branch.

It is estimated that between 0.2 and 2 percent of the approximate 220,000 km. (85,000 sq.mi.) area, lying beyond the jurisdiction of fire management, is burned annually. Continuous cover types rarely escape the ravages of wildfire during a biological life cycle of 250 years. Consequently, most forest stands are less than 100 years of age.

Measurements of jack pine and black spruce regeneration growing on optimum sites, show that after 10 years, trees are only 0.3 meter tall; at 15 years, 1.5 m., and up to 4 m. at age 25, a range of from 3 centimeters (1.2 in.) to 16 cm. (6.3 in.) per year. Trees rarely exceed 12 meters (40 ft.), in height and 20 cm. (8 in.), diameter at breast height. Ages of forest stands are generally between 45 and 115 years.

Colour transparancies of Landsat images, dating from 1972 to 1983, were examined to delineate recent wild fires that had occurred during this interval and to estimate previous areas burned between 1950 and 1960 and 1961 to 1971. Landsat

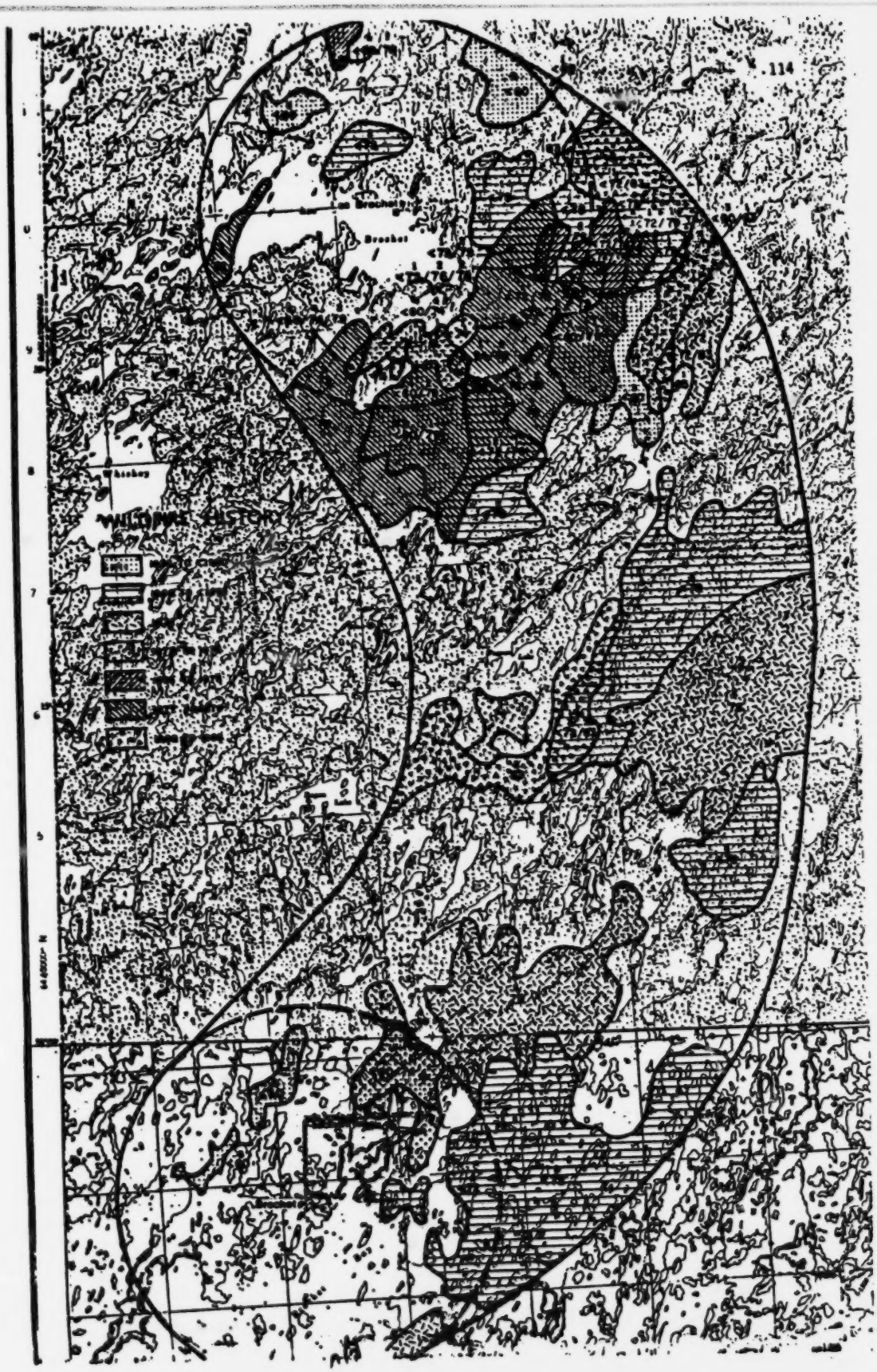
resource satellites have been recording repetitive coverage of the earth's surfaces since July 1972. The satellite scenes were viewed, using a 3 diopter, illuminated magnifier and an optically diffused, projection table. The photo scale of the images was approximately 1:1,000,000, 1 inch = 16 miles (26 km.).

Fire boundaries are discernible on satellite scenes as based upon colour contrasts. Distinct changes are evident, owing to the absence of living vegetation on recently burned sites, (dark tones) and the intensity of regenerating forest and ground cover on older burns, (light tones). Areas that have not experienced fires for perhaps the past 50 years have mid tones.

Fire perimeters were marked on an overlay and projected onto a 1:250,000, 1 in. = 4 mi.(6 km.), base map. (See accompanying reduction Map 6-2). Computations for burned and unburned areas were derived using a polar planimeter. The areas of Reindeer Lake and Lac Brochet, the largest lakes in the study area, were also calaulated by planimeter. A visual estimate of the percentage contained by smaller water bodies lying within each fire boundary was deducted from the burned areas. Previous fire areas, situated within new fires, were also subtracted to arrive at a net total burned figure for Brochet, Lac Brochet and the Cochrane River corridor as summarized below:

	km^2	sq.miles	%
Burned Area	1,522	588	37
Unburned Area	1,540	595	37
Water	1,078	416	26
Total Area	4,140	1,599	100

The data indicates that 50% of the land surface has been devastated by wild fire in the last 33 years. The annual rate of burn for this period has been 1.5% which amounts to 46 km^2 (18 sq. miles) roughly half a township per year.



MAP 6-2

TABLE 6-1: WILDFIRE HISTORY SATELLITE MAPPING - LANDSAT IMAGES 1972-1983

BURNED AREAS - BROCHET - LAC BROCHET - COCHRANE RIVER CORRIDOR AREAS

YEAR FIRE	BROCHET km	BROCHET sq mi	LAC BRO km	LAC BRO sq mi	CORR... km	CORR.... sq mi	TOTALS km	TOTALS sq mi
>1950 to <1960 FIRES - LANDSAT IMAGE - 24 AUGUST 1972								
<60-1	26.2	10.7	6.9	2.6	4.4	1.7	37.5	15.0
<60-2	16.1	6.2	10.5	4.1	41.1	15.9	67.7	26.2
<60-3	6.9	2.7	26.6	10.3	77.4	29.9	110.9	42.9
<60-4	- -	- -	34.3	13.2	1.2	0.5	35.5	13.7
50/60	49.2	19.6	78.3	30.2	124.1	48.0	251.6	97.8
>1960 to <1972 FIRES - LANDSAT IMAGE - 24 AUGUST 1972								
<72-1	43.5	16.8	58.0	22.4	82.2	31.8	183.7	71.0
<72-2	8.1	3.1	17.7	6.9	60.6	23.5	86.4	33.5
<72-3	- -	- -	1.2	0.5	169.7	65.6	170.9	66.1
<72-4	- -	- -	- -	- -	60.6	23.5	60.6	23.5
<72 5	- -	- -	- -	- -	168.9	65.2	168.9	65.2
60<72	51.6	19.9	76.9	29.8	542.0	209.6	670.5	259.3
1972 FIRES - LANDSAT IMAGE - 24 AUGUST 1972								
72-1	15.3	5.9	- -	- -	36.3	14.0	51.6	19.9
72-2	- -	- -	- -	- -	172.9	66.8	172.9	66.8
72-3	- -	- -	- -	- -	105.6	40.8	105.6	40.8
72-4	- -	- -	- -	- -	1.2	0.5	1.2	0.5
72-5	15.3	5.9	- -	- -	316.0	122.1	331.3	128.0
1973 & 1974 FIRES - LANDSAT IMAGE - 14 AUGUST 1974								
74-1	12.9	5.0	10.5	4.0	15.7	6.1	29.1	15.1
74-2	- -	- -	- -	- -	7.7	3.0	7.7	3.0
74	12.9	5.0	10.5	4.0	23.4	9.1	46.8	18.1
1975 & 1976 FIRES LANDSAT IMAGE / 26 SEPT. 1976								
76-1	- -	- -	(6.9)	(2.7)	(14.1)	(5.5)	(21.0)	(8.1)
76-2	- -	- -	(2.4)	(0.9)	- -	- -	(2.4)	(0.9)
76-3	- -	- -	(16.5)	(6.4)	- -	- -	(16.5)	(6.4)
76	- -	- -	(25.8)	(9.9)	(14.1)	(5.5)	(39.9)	(15.4)
1977 to 1979 FIRES LANDSAT IMAGE / 15 AUGUST 1979								
79-1	- -	- -	12.9	5.0	- -	- -	12.9	5.0
79-2	- -	- -	68.5	26.5	74.6	28.8	143.1	55.3
79	- -	- -	81.4	31.5	74.6	28.8	156.0	60.3
1980 to 1983 FIRES LANDSAT IMAGE / 04 AUGUST 1983								
83-1	- -	- -	0.4	0.2	1.6	0.6	2.0	0.8
83-2	- -	- -	- -	- -	64.5	24.9	64.5	24.9
83	- -	- -	0.4	0.2	66.1	25.5	66.5	25.7
TOTAL AREAS BURNED BY WILDFIRE - >1950 to 1983								
50-83	129.0	50.4	247.5	95.7	1146.2	443.1	1522.7	589.2

WILDFIRE SUMMARY - BROCHET - LAC BROCHET - COCHRANE RIVER AREAS

YEARS	AREA	WATER	%	BURNED	%	UNBURNED	%	TOTALS	%
50-83	BROCHET	320/123	8	129/ 50	3	355/137	8.5	804/ 310	19.5
	LAC BRO	245/ 95	6	247/ 95	6	312/120	7.5	804/ 310	19.5
	COCHRANE	502/194	12	1146/443	28	861/332	21.0	2509/ 969	62.0
	TOTALS	1067/412	26	1522/588	37	1528/589	37.0	4117/1589	100.0

6.3 Fuel Wood Assessment

6.3.1 Fuel Wood Reserves:

The gross total wood volumes within unburned forest ecotypes and the remaining net volumes of dead wood found on burned areas were calculated to show the total fuel wood reserves.

The net total volume per hectare shown in Fuel Wood Volume Reserves, Table 6-2, indicate that Upland Open Lichen - Spruce forests produce 2 cords per hectare; both Upland and Lowland Open Forests support 5 cds./ha. while Upland and Lowland Closed Forests grow 12 cds. /ha. In contrast, the gross total volumes (G.T.V.) are 3.5 cds./ha. for Upland Open Lichen - Spruce; Upland Open Spruce / Pine 8.0 cds./ha., Upland Closed Spruce / Pine 20.0 cds./ha., Lowland Open Spruce 6.5 cds./ha. and Lowland Closed Spruce Forest is 21.5 cds./ha. The G.T.V. is 30% to 80% higher than the Given Merchantable Volume, (G.M.V.).

Two factors must be considered in calculating volumes for burned and unburned areas. Firstly, it is expected that at least 50% of the G.T.V. is consumed by fire reducing the volumes on burned areas to the G.M.V. levels of 2, 5 and 12 cords/ha. Secondly, G.T.V. can quite safely be applied to the unburned areas since tree tops and stumps contribute a significant volume increase. Also, trees that are just below the merchantable diameter limit of 9.1 c.m. (3.6 in.) provide additional wood volume. Therefore, the Brochet and Lac Brochet fuel wood volume reserves, Table 6-2, lists Net Total Volume (N.T.V.) comparable to G.M.V. for burned areas and G.T.V. for unburned areas.

6.3.2 Fuel Wood Requirements:

One of the most debatable and unanswered questions is: what is the average number of cords of fuel wood that is required and hauled, per household, for home heating use? Based on British Thermal Unit ratings, between 11 and 14 cords are required to heat a dwelling with an adequate level of insulation, under subarctic climatic conditions. However, since most homes lack an acceptable level of R Factor insulation rating for this climatic zone, the volume of fuel wood utilized annually per household is likely closer to 16 to 18 cords. Regardless of the volume per load, the cost of $765.00 to haul 45 loads still prevails and will escalate in the future as access distance increases with volume of wood harvested.

An attempt has to be made to calculate the volume per load in order to determine the projected volume requirements and the depletion rate of the fuel wood reserves. Therefore, it is assumed that each load contains the equivalent of 30 average sized tree lengths with a 10 cm. diameter and height of 8 m., containing .030 m. G.T.V. per tree. This represents 0.375 cords per load or 17 cords per household per year. The only feasible way to confirm the consumption rate would be to monitor cutting and hauling activities.

6.3.3 Projected Consumption and Remaining Volume:

It is projected that 268,000 loads or 100,500 cords of fuel wood will be utilized over the next 25 years, at present rates of consumption. This will deplete the

present burned area volumes from 225,900 to 125,000 cords. Much of the remaining volume will have fallen and decomposed in the interim. The combined 376 km. burned area will be depleted and will remain devoid of potential volume for at least the next 60 to 90 years after regeneration has become established and recurring fires, once again, affect these areas.Recent burns outside of the 16 km. radii are likely frequented to obtain fuel wood, although this was not considered in calculating total fuel wood reserves.

The present wood volume of the unburned areas is about 633,400 cords, bringing the total fuel wood reserve to 859,300 cords. Green standing timber is considered too heavy to haul, more difficult to cut and limb and is usually rejected in preference to light and dry, dead trees. However, living trees are cut but not stock-piled to dry. There is no imminent threat of depleting the fuel wood resource, based upon the more than ample fuel wood reserves. However, it is also important to note that replenishment period and repeated fires may predispose the acquisition of fuel wood within a reasonable distance from the communities.

TABLE:6-2: FUEL WOOD VOLUME RESERVES - NET TOTAL AND GROSS TOTAL VOLUMES

BROCHET: 16 KILOMETER RADIUS

BROCHET BURN AREAS - NET TOTAL VOL.					UNBURNED AREAS - GROSS TOTAL VOL.				
UPLAND OPEN LICHEN - SPRUCE FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
5 %	6.5	650	2.0	1,300	5 %	18.0	1,800	3.5	6,300
UPLAND OPEN SPRUCE / PINE FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
45 %	58.0	5,800	5.0	29,000	45 %	160.0	16,000	8.0	128,000
UPLAND CLOSED SPRUCE / PINE FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
15 %	19.5	1,950	12.0	23,400	15 %	53.0	5,300	21.0	111,300
LOWLAND OPEN SPRUCE FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
25 %	32.0	3,200	5.0	16,000	25 %	88.0	8,800	6.5	57,200
LOWLAND CLOSED SPRUCE FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
5 %	6.5	650	12.0	7,800	5 %	18.0	1,800	21.5	38,700
LOWLAND SEDGE / SHRUB FEN NON - FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
5 %	6.5	650	Nil	Nil	5 %	18.0	1,800	Nil	Nil
BROCHET TOTALS									
NET TOTAL VOLUME - BROCHET BURNED					GROSS TOTAL VOL.- BROCHET UNBURNED				
AREA%	Km.	HECTARES	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
100 %	129.0	12,900		77,500	100 %	355.0	35,500		341,500

LAC BROCHET: 16 KILOMETER RADIUS

LAC BROCHET BURN AREAS - NET TOT.VOL					UNBURNED AREAS - GROSS TOTAL VOL.				
UPLAND OPEN LICHEN - SPRUCE FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
5 %	12.5	1,250	2.0	2,500	5 %	16.0	1,600	3.5	5,600
UPLAND OPEN SPRUCE / PINE FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
45 %	111.0	11,100	5.0	55,500	45 %	140.0	14,000	8.0	112,500
UPLAND CLOSED SPRUCE / PINE FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
15 %	37.0	3,700	12.0	44,400	15 %	47.0	4,700	21.0	98,700
LOWLAND OPEN SPRUCE FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
25 %	62.0	6,200	5.0	31,000	25 %	78.0	7,800	6.5	50,700
LOWLAND CLOSED SPRUCE FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
5 %	12.5	1,250	12.0	15,000	5 %	16.0	1,600	21.5	34,400
LOWLAND SEDGE / SHRUB FEN NON - FOREST ECOTYPE									
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
5 %	12.0	1,200	Nil	Nil	5 %	15.0	1,500	Nil	Nil
LAC BROCHET TOTALS									
NET TOTAL VOL. - LAC BROCHET BURNED					GROSS TOT.VOL.- LAC BROCHET UNBURNED				
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
100 %	247.0	24,700		148,400	100 %	312.0	31,200		301,900
GRAND TOTALS BROCHET - LAC BROCHET									
NET TOT. VOL: BRO.- LAC BRO. BURNED					GRO.TOT.VOL: BRO.- LAC BRO. UNBURNED.				
AREA%	Km.	Hectares	Cd/ha	N. T. V.	AREA%	Km.	Hectares	Cd/ha	G. T. V.
100 %	376.0	37,600		225,900	100 %	667.0	66,700		643,400

TOTAL BURNED AND UNBURNED AREAS: 1,043 Km. 104,300 Hectares

FUEL WOOD VOLUME RESERVES: 869,300 CORDS (NET TOTAL AND GROSS TOTAL VOL.)

7.

SMALL HYDRO & CENTRAL GRID TRANSMISSION INTERCONNECTION

7. SMALL HYDRO & CENTRAL GRID TRANSMISSION INTERCONNECTION

This section of the report presents the results of a pre-feasibility engineering study of hydroelectric development of the Cochrane River, and the cost estimation of a transmission line to the Manitoba Hydro grid at Lynn Lake. These studies included the estimation of capital and operating costs of these alternatives.

The estimates of future electrical loads in the study area, as described in Section 4, formed the basis for identification of alternative energy sources. The load projections for the combination of Brochet and Lac Brochet are summarized in Table 7-1.

7.1 Cochrane River - Hydrology

A detailed description of the hydrological work undertaken in this study is given in Appendix E. The following main points summarize the results:

- the flow in the Cochrane River follows the annual pattern typical of subarctic rivers - relatively high spring and summer flows resulting from snowmelt runoff and summer rains, with receding flows in fall and winter, and the lowest flow of the annual cycle in late winter before the spring thaw. This pattern is tempered somewhat on the Cochrane by the natural regulation provided by Wollaston Lake.

- the Cochrane River has a long term mean flow of approximately 150 m^3/s near Brochet and 130 m^3/s at the outlet of Lac Brochet.

- the minimum, or firm flow, is estimated to be 55m^3/s which occurred in the winter of 1957, and is likely the lowest flow

Load Projections - Brochet & Lac Brochet Table 7-1

Load Case	1983 Peak (kw)	1983 Energy (MWh)	1993 Peak (kw)	1993 Energy (MWh)	2008 Peak (kw)	2008 Energy (MWh)
Low 15 amp. Restricted	280	1,160	420	1,760	740	3,180
Intermediate Unrestricted but without Electric Heat	280	1,160	1,260	4,280	2,330	7,800
High Unrestricted with Electric Heat	280	1,160	2,910	9,400	5,330	17,500

since 1929. The normal late winter flow is approximately 100 m^3/s.

- the maximum recorded flow is 388 m^3/s near Brochet and approximately 320 m^3/s at the outlet of Lac Brochet. This occurred in July, 1977, and is estimated to be the highest flow since 1929.

7.2 Hydro Site Selection

The Cochrane River drops some 25 m over a distance of about 115 km from Lac Brochet to its outlet at Reindeer Lake. Potential for hydroelectric development of some of this head exists in three main areas:

- in the lower 15 km of the river
- in the upper 25 km near the outlet of Lac Brochet
- at a diversion route through Kakanukamak and Engen Lakes to Birch Bay on Reindeer Lake.

The most promising sites in these areas were selected from aerial photographs and topographic maps, visited by environmental and hydroelectric specialists and compared in terms of relative costs as described in Appendix F. It was found that for the low and intermediate load cases, a development at Axis L-3 near Brochet (see Plate 7-1, Appendix F) would give the least-cost option. For the high load case, however, the dam height required at Axis L-3 would cause extensive flooding of the river banks, and would be expensive. The least-cost option for the high load case was found to be a diversion scheme through Engen Lake to Birch Bay (Plate 7-2, Appendix F).

7.3 Preferred Schemes

7.3.1 Type of Generating Units

In plants of the size and head required for the Cochrane River, tubular turbine/generator units are commonly used. These units have the advantage of requiring little excavation, and a minimum volume of concrete in the structure which contains them. They are available from standardized designs so that the cost of design is minimized, and reliable, predictable instaliation is assured. They also are delivered largely pre-assembled and require a minimum of on-site assembly. These units have been assumed in the layouts and preliminary cost estimates described below.

7.3.2 Low Load Case

The best hydro development for the low load case is considered to be at the rapids approximately 14 km northeast of Brochet, identified as Axis L-3 on Plate 7-1.

The arrangement of structures for this case is as shown generally on Plates 7-3 and 7-4 (both in Appendix F) and includes the following (dimensions of the powerhouse for the low load case would be somewhat smaller than shown on these plates):

Overflow Weir

- constructed across the river at the brink of the rapids to raise the upstream water level by approximately 2.5 m. This supplements the natural 2.5 m drop of the rapids and, for a given plant output, significantly reduces the size

and cost of the turbines and powerhouse. It also permits the formation of a solid ice cover in winter which would inhibit the formation of frazil ice that could clog the intakes to the turbines and cause plant shutdowns.

- there are several options for the construction of this weir. The most reliable and longest lasting but also the most expensive would be with concrete; other less expensive options include gabions, timber, and timber/rockfill cribs. Selection of the optimum method would require further study and should be reserved for the feasibility level of study which would be required if the hydro option is pursued.

- the overflow weir would be constructed in the dry behind an earthfill cofferdam built upstream across the river.

- the river would be diverted through a channel cut in the rock of the west shore which would later house the generating units; closure of the diversion channel prior to the powerhouse construction would be done either by jacking timber stoplogs into slots in previously constructed piers in the channel or by transverse dumping of rock from a temporary deck across the channel. A possible option for this diversion would be through the gully located 500 m east of the rapids.

Intake/Powerhouse

- the intake/powerhouse would be a reinforced concrete structure to house two 250 kw tubular units and a service area for maintenance of the units.

- the intake would include trashracks at the upstream end and guides for timber stoplogs which would be required for dewatering the units.

- the intake deck would serve as an access route during the construction of the weir. Servicing of trashracks and installation of stoplogs will also be done from the intake deck, when it is required.

- the powerhouse portion of the structure consists of the tubular turbine embedded in concrete with a reinforced concrete draft tube extending downstream.

- the superstructure over the powerhouse and service area consists of a structural steel frame supported on the concrete, with insulated cladding and roof deck.

- the units would each use up to approximately 6 m^3/s of the river flow, with the remainder of flow passing over the weir. Tubular turbines would be equipped with stationary guide vanes, moveable turbine blades, a speed increaser and synchronous generator.

- two units would be installed initially, with provision to install a third as the electrical load in the two communities grows in future years. The provision would involve the excavation of the approach and tailrace channels, and the excavation for the future unit. A temporary timber crib dam would be constructed to block off the excavated pit for the future units.

Dykes

- dykes would be required on both banks to tie into high ground.

- they would be constructed of rockfill obtained from the excavation of the diversion channel, and would have a compacted glacial till seal on the upstream face.

- some dyking also will be necessary to close the gully which runs parallel to and about 500 m east of the river. As noted above, this may be an option for a diversion channel during construction.

Reservoir

- the project would impound a small reservoir by raising the upstream water level by about 2.5 m. This would drown out the next set of rapids approximately 1.5 km upstream, but no significant increases in water level would extend upstream from that location.

- the reservoir would flood a narrow band of land (typically 2 to 50m wide) on both sides of the river for a distance of some 1.5 km upstream of the structures. This flooded area of approximately 10 hectares would be cleared to minimize the volume of floating debris.

- operation of the hydro plant to meet the varying load would cause some minor fluctuation in the reservoir level on a daily basis. For example, under normal flow conditions the upstream level could fluctuate about 0.2 m from the low load period in the night to the high load period in late

afternoon. However, the total flow released through the project would remain approximately the same as under natural conditions. Similarly, downstream water levels would be unaffected.

Transmission Lines

- transmission lines to both communities would be required. A tentative route is shown on Plate 7-1. They would be strung on single wood poles with access for construction by winter road. The lengths would be approximately 15 km to Brochet and 85 km to Lac Brochet.

Access

- access to the site during construction and for subsequent maintenance would be via a gravel-surface, single lane road from Brochet.

7.3.3 Intermediate Load Case

The preferred scheme for this case was determined to be similar in arrangement to that described for the low load case. The powerhouse would be of the same type, but somewhat larger to house two 600 kW tubular units, with provision to add a third and a fourth in future years as the load increases. All other components of the project would be similar to that described for the low load case. The general arrangement of the structures at L-3 is shown on Plate 7-3, with cross-sections of the powerhouse and weir on Plate 7-4. The dimensions shown are for the 600 kW units (intermediate load case), but the general position and arrangement of the structures would be the same for the 250 kW units (low load case).

7.3.4 High Load Case

With frequent late winter flows of 75 m^3/s or less, the development of 5,000 kW requires a head approaching 9 m. While this is conceivable at Axis L-3, it would likely involve expensive abutment treatment to avoid seepage problems through the granular terrace forming the east bank. Also, such an impoundment would require a relatively expensive spillway and earthfill dam to impound the reservoir. Flooding would extend some 50 km upstream. In general, such a development appears to be less attractive than other alternatives studied.

The preferred scheme for a development of 4,000 to 5,500 kW involves a diversion of a portion of the Cochrane River flow through Engen lake to its outlet to Birch Bay (Reindeer Lake) where a head of 11 m can be used to generate power. The diversion scheme involves the following components which are shown on the location map on Plate 7-2.

Rockfill Groin

- this would be built above Kamacheechawasik Rapids on the Cochrane River about 48 km upstream of Reindeer Lake. This would increase the water level by about 1 to 2 m upstream so that a portion of the river flow could be diverted through Kakanukamak Lake to Engen Lake.

- access for construction or for future maintenance work if required, would be by winter road from the powerhouse location.

Channel Excavation

- a short channel (approximately 80 m long) would be excavated between the Cochrane River and Kakanukamak Lake.

- a 400 m long channel at the inlet to Engen Lake would be required.

- some excavation would likely be required in the natural channels at the outlet of Kakanukamak Lake, and at the entrance and outlet of Engen Lake.

- the diversion of flow would be up to approximately 45 m^3/s which is about half the normal late winter flow.

Freeboard Dykes

- freeboard dykes would likely be required at the southwest corner of Kakanukamak Lake to avoid spillage from the catchment area through Muskeko Lake.

- these would be accessed by winter road for both construction and future maintenance, if required.

Rockfill Dam

- the creek which now flows from Engen Lake to Birch Bay (Reindeer Lake) would be blocked by an 8 m high rockfill dam with a sand filter zone and a compacted glacial till seal on its upstream face, with riprap protection against waves.

Intake/Powerhouse

- a reinforced concrete intake structure would be tied into the rockfill dam. It would house three intakes each equipped with trashracks and guides for timber stoplogs. The third intake would be blocked initially with stoplogs until the third unit is required.

- flow would be carried down short penstocks from the intakes to the powerhouse. The penstocks would be covered by a layer of soil to act as insulation.

- the powerhouse would house two 1,750 kW turbine/generators with excavation provided for a future third unit required for anticipated load growth.

- outflow from the powerhouse would pass through an excavated tailrace channel to a nearby arm of Birch Bay. The total developed head would be approximately 11 metres.

Reservoir

- the reservoir of the plant would be the natural water body of Engen Lake.

- the level of Engen Lake would be about 1 m higher than its natural condition. This is likely within the natural range of the lake levels and clearing along the lakeshore would likely not be required.

Transmission

- transmission lines to both communities would be required, and tentative routes are shown on Plate 7-2. They would be strung on single wood poles with access for construction by winter road. The lengths would be approximately 32 km to Brochet and 70 km to Lac Brochet.

Access

- access to the site during construction would be via barge in summer, winter road from Brochet to the site, and by helicopter service.

- continued access for operation and maintenance would be by boat, snowmobile in winter, supplemented by all-terrain vehicles and/or helicopter service if required in spring and fall when breakup or ice formation would prevent boat or snowmobile access.

7.4 Construction Schedules

It is considered that any of the schemes studied could be constructed in some 15 to 18 months. This would involve construction of the access road and some preparation of the site in the fall, with full mobilization of the contractor and camp setup in winter in preparation for an early start of construction in spring. The manpower required in site work for the intermediate load case would be approximately 25 man years, with a peak force of 60 men. An approximate schedule for the Axis L-3 scheme (intermediate load case) is shown in summary form in Table 7-2. The low-load case, also at Axis L-3, would be on an almost identical schedule.

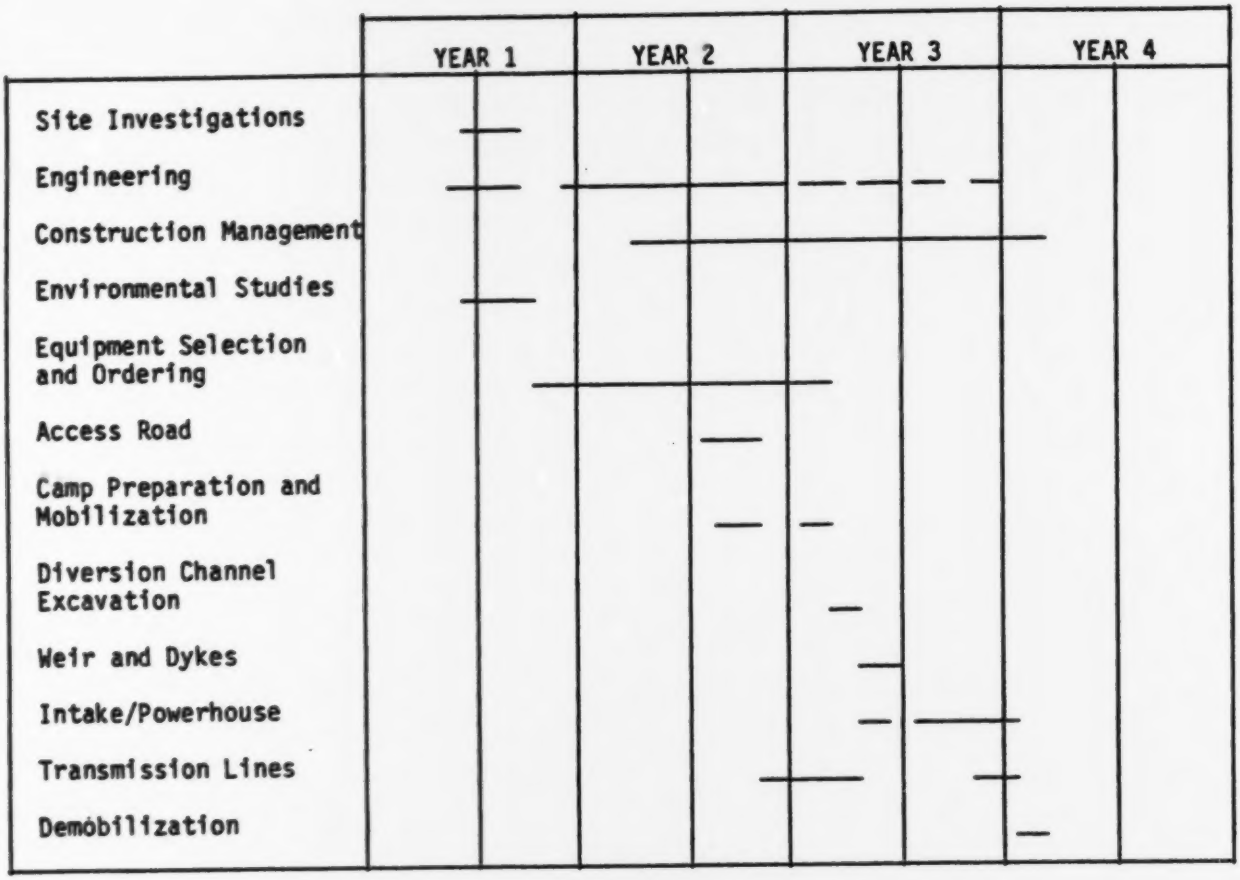
Construction of the diversion scheme would involve mobilization and camp setup in the fall prior to the main construction season of the following summer. The rockfill groin, the channel excavation and the wing dykes would be built in the winter and spring. Construction at the main site including the intake/powerhouse and the dam would be done in the summer and fall, with demobilization by the end of the year.

Transmission line construction for all cases would be in winter and early spring with access by winter road, all-terrain vehicle, and helicopter as required.

TABLE 7-2

APPROXIMATE CONSTRUCTION SCHEDULE

FOR AXIS L-3 (Intermediate Load Case)



7.5 Cost Estimates

7.5.1 Hydro

During the study of the Cochrane development it was considered that an effective means of estimating the costs of the numerous alternatives of axes and plant sizes would be to concentrate on a more detailed cost estimation for a single option. Costs for the other options were then adjusted appropriately where they were different from the base case. This base was chosen to be the intermediate load case, with the development at Axis L-3 as described above in Sections 7.3.2 and 7.3.3. The main items of this cost estimate are summarized in Table 7-3. The cost of installation of the future units is itemized in Table 7-4.

This capital cost estimate is based on limited information regarding the site and on preliminary design. It is judged that, under present market conditions, the actual cost of such a power development today may vary within a range from 10 percent less to 20 percent greater, or from $11,700,000 to $15,600,000. If the hydro option appears attractive from the present study, site investigations and more detailed design associated with the next phase of study will lead to a new estimate with less spread between optimistic and pessimistic limits.

Several basic assumptions should be cited to qualify the cost estimate:

- there has been no allowance for land acquisition costs and it is assumed that the land at the site, and for the access road and transmission lines can be leased from the crown at a nominal cost.

- there has been no direct allowance for the construction of a winter road across Reindeer Lake for transport of materials and equipment to Brochet. It is assumed that the winter road which has been used in recent years for hauling diesel fuel and other goods can be used on a shared cost basis.

- it has been assumed that the nursing station at Brochet can be used to treat work-related injuries without requiring additional facilities. No allowance has been made for the transport of injured workers to an outside treatment centre such as Lynn Lake or Thompson.

- there has been no allowance for the cost of mitigative measures for environmental impacts of the project, mainly because these impacts are considered to be minor.

- the allowance for camp construction and catering assumes a standard of subsistence for workers which is comparable to that at Manitoba Hydro's northern developments.

Cost estimates for the other load scenarios have been prepared in a similar fashion and the total costs have been summarized in Table 7-5. The range of accuracy in these estimates (except for the 1,200 kW scheme at L-3) is judged to be -15% to +30%.

The relatively high cost of the transmission line between the two communities suggests the possibility of developing two sites - one at Axis U4 located about 3.5 km upstream of Chipewyan Falls (see Figure A-2 in Appendix F) to serve Lac Brochet, and the other at Axis L-3 to serve Brochet. The combined costs are more than for the single development.

The estimates are expressed in 1984 dollars and include an allowance for interest on capital spent during construction based on an assumed interest rate of 5%.

These combined estimates, as well as the costs for single development, are summarized in Table 7-5.

TABLE 7-3

PRE-FEASIBILITY COST ESTIMATE FOR INITIAL 1200 kW AT AXIS L-3 (INTERMEDIATE LOAD CASE)($1984)

ITEM DESCRIPTION	QUANTITY	UNIT PRICE	COST	ITEM TOTAL
1. Contractor Mobilization and Site Preparation				650,000
2. Diversion Channel				
approach	5,000 m^3	$18	90,000	
powerhouse	3,000 m^3	$18	57,600	184,000
tailrace	2,000 m^3	$18	36,000	
3. Cofferdams				
- for weir construction	Lump sum Including Removal		90,000	
- for diversion channel and powerhouse	Lump sum Including Removal		70,000	160,000
4. Dykes				
- Tie-in to Weir and Powerhouse	2,500 m^3	$12	30,000	
- Wing-Dyke 500 m upstream of Axis L-3	4,000 m^3	$15	60,000	90,000
5. Weir (Rockfill crib)	1,500 m^3	$130	200,000	200,000
6. Retaining Wall at East Bank	220 m^3	$500	110,000	110,000
7. Concrete Dam	100 m^3	$500	50,000	50,000
8. Intake/Powerhouse Concrete	1,400 m^3	$500	700,000	
Rockfill-crib at Intake for temporary blockage of future Units 3 and 4.	400 m^3	$100	40,000	
Turbine/Generators (2 - 600 kW units)	Lump Sum		1,600,000	

Table 7-3 (cont'd)
($1984)

ITEM DESCRIPTION	QUANTITY	UNIT PRICE	COST	ITEM TOTAL
Superstructure with crane	Lump Sum		180,000	
Accessory Electrical Equipment	Lump Sum		350,000	
Miscellaneous Mechanical Equipment	Lump Sum		180,000	
Switchyard	Lump Sum		200,000	3,150,000
9. Site Storage During Construction	Lump Sum			100,000
10. Demobilization and Camp Cleanup	Lump Sum			70,000
11. Transmission				
- transformers	Lump Sum		60,000	
- breakers & miscellaneous items	Lump Sum		80,000	
- transmission lines	100 km	$25,000	2,500,000	
- brush clearing	100 km	$ 8,000	800,000	3,440,000
12. Reservoir Clearing	10 hectares	$ 2,000		20,000
13. Allowance for unforeseen items				400,000
			SUBTOTAL DIRECT COSTS	$ 8,624,000
14. Site Explorations				200,000
15. Preliminary Engineering				150,000
16. Construction Camp and Catering				900,000
17. Access Road	15 km	$67,000		1,000,000

Table 7-3 (cont'd)

($1984)

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ITEM DESCRIPTION	QUANTITY	UNIT PRICE	COST	ITEM TOTAL
18. Owner's Administration Environmental Studies Final Project Design Construction Management				1,300,000
19. Interest During Construction				800,000
		TOTAL APPROXIMATELY		$13,000,000

Note: This total cost estimate is based on limited information regarding the site and on preliminary design. It is judged that, under present market conditions, the actual cost of such a power development today may vary within a range from 10 percent less to 20 percent greater, or from $11,700,000 to $15,600,000.

TABLE 7-4

PRE-FEASIBILITY COST ESTIMATE OF ADDING ONE 600-kW UNIT AT AXIS L-3 ($1984)

ITEM DESCRIPTION	COST	ITEM TOTAL
1. Contractor Mobilization		$ 150,000
2. Intake Powerhouse		
-timber crib downstream cofferdam, & dewatering	$ 30,000	
-concrete (700 m^3 at $550/$m^3$)	385,000	
-turbine/generator unit	800,000	
-superstructure	50,000	
-accessory elect. equip.	150,000	
-miscellaneous equipment	35,000	
-switchyard expansion	40,000	
-removal of dam timber crib temporary headblock	10,000	1,500,000
3. Site Storage	20,000	20,000
4. Demobilization	20,000	20,000
5. Allowance for unforeseen items		100,000
Subtotal Direct Costs		$1,700,000
6. Construction Camp and Catering		300,000
7. Owner's Administration Final Design Construction Management		400,000
8. Interest During Construction		130,000
TOTAL APPROXIMATELY		$2,600,000

TABLE 7-5

ESTIMATED CAPITAL COSTS FOR HYDRO PLANT OPTIONS ($1984)

LOAD CASE	COST ESTIMATES (1984 $)		
	SINGLE SITE TO SERVE BROCHET AND LAC BROCHET	SINGLE SITE FOR BROCHET ALONE	SINGLE SITE FOR LAC BROCHET ALONE
LOW 15 amp restriction	Axis L-3 2 - 250 kW units initially - $11,500,000 1 - 250 kW unit in 1994 - $2,000,000	Axis L-3 2 - 175 kW units initially - $6,000,000 1 - 175 kW unit in 1994 - $1,900,000	Axis U-4 2 - 100 kW units initially - $7,000,000 1 - 100 kW unit in 1997 - $1,800,000
INTERMEDIATE 100 amp no electric heat	Axis L-3 2 - 600 kW units initially - $13,000,000 1 - 600 kW unit in 1991 - $2,600,000 1 - 600 kW unit in 1997 - $2,600,000	Axis L-3 2 - 500 kW units initially - $9,000,000 1 - 500 kW unit in 1995 - $2,500,000	Axis U-4 2 - 300 kW units initially - $8,200,000 1 - 300 kW unit in 1995 - $2,200,000
HIGH 100 amp with electric heat	Diversion Scheme 2 - 1,750 kW units initially - $24,000,000 1 - 1,750 kW unit in 1994 - $3,800,000	—	—

7.5.2 Transmission Tie-Line With Manitoba Hydro

One alternative for supply of electricity to Brochet and Lac Brochet is a 225 km long transmission line from Lynn Lake, the nearest location of the Manitoba Hydro grid system. In collaboration with Manitoba Hydro, the cost of a 5 MVA, 66 KV line has been estimated in mid-1984 dollars as follows:

Lynn Lake/Brochet	
- breaker at Lynn Lake and line termination	$ 400,000
- transmission line, 2/0 ASCR on single wood poles, at $30,000 per km (145 km)	4,350,000
- brush clearing, $8,000 per km	1,160,000
- station at Brochet to interface with distribution system; two 5 MVA 66 kV/12 kV transformers (one backup) with some regulation	1,350,000
- interest during construction	400,000
Total	$7,680,000

This cost includes all materials, installation and all costs to Manitoba Hydro such as design, construction camp, labour, management, etc.

Brochet/Lac Brochet	
- breaker at Brochet and line termination	$ 400,000
- transmission line $30,000/km (80 km)	2,400,000
- brush clearing $8,000/km	640,000
- station at Lac Brochet	1,350,000
- line reactors for stability	400,000
- interest during construction	250,000
Total	$5,460,000

In addition to this capital cost, Manitoba Hydro would charge for residential energy usage at the rate of approximately 5.9¢ per kWh up to 250 kWh per month and 3.0¢ per kWh above 250 kWh per month, as well as a $9.44 service charge.

The construction of the transmission line from Lynn Lake would be performed during winter with access over winter roads. It is likely that the construction could be completed in two winter seasons, but further study and planning by Manitoba Hydro would be required to confirm this.

7.6 Operation and Maintenance

The hydro plant would be designed to operate unattended with supervisory control in Brochet. Maintenance beyond the normal weekly and monthly upkeep would likely require experienced personnel from a southern centre such as Lynn Lake or Thompson. It has been found from experience at hydroelectric plants in North America that the annual cost of operation and maintenance is approximately 1 to 2% of the capital cost of the plant and transmission system. In planning, Manitoba Hydro assumes approximately 1.7% for plant operation and maintenance and 1.2% for transmission lines. These O/M estimates were utilized for purposes of this report.

It is important to note that capital, operating and maintenance charges for small hydro include the provision of electrical energy. The cost of water rentals has not been included in the hydroelectric analysis. The capital, operating and maintenance charges for transmission tie-in include the physical operating and maintenance of the transmission line only. An additional charge for the electrical energy which is transmitted along the line has been considered in this analysis.

7.7 Reliability of Electrical Supply

In view of the isolation of the communities, ie. no connections to any other system to provide alternate sources of electrical power in the event of generating equipment failure, the reliability of electrical supply is a critical topic. This is true whether the power is provided by diesel generation, land line, or a small hydroelectric development. In the case of diesel generation, spare generators provide back-up supply. However, in the case of a land line it would be economically unrealistic to provide a second line to account for failure due to icing on the lines for example. Similarly, if it is expected that most of the output from two generators will be necessary to meet anticipated peak future needs, then a third back-up hydro generator would add significantly to the cost.

In addition, it is also important to consider the cost of providing adequate generating capacity at this time to meet the highest possible potential peak demands many years from now.

Three potential alternatives to deal with the above are:

1) Utility controlled load shedding, that is, the ability of the utility to shed pre-determined loads in each building. For example, in the event of an unexpected high demand or the failure of one of the generators or transformers, the utility could send a signal over the power lines to shed non-essential loads, perhaps hot water heating, electric clothes dryers, or even a portion of the heating system, leaving only sufficient heat to prevent a freezing condition.

1) con't
This concept could be extended to the sophistication of various priorities of shedding, so that initially, the frequency of the signal transmitted over the lines would shed only the least essential loads. If the situation continued to deteriorate, successively more essential loads would be shed.

2) A requirement that all future homes that are electrically heated must have combination wood/electric forced air furnaces and that a back-up wood supply be available. Therefore, in the event of an emergency, the amount of electricity supplied to a home would be sufficient to power the furnace fan but not the electric heating elements. However, a forced air furnace would be more expensive than baseboard heaters and this would be particularly true in the case of retrofitting existing homes.

3) A requirement that every home must have a small wood stove in a key area (survival corner), in the event of a total power failure so that the water lines in the home could be easily drained and that the small stove would provide a temporary warm area for living as well as keeping the home larder, the hot water tank, etc. from freezing.

Acceptance of the above concepts implies that these conditions would have to be adopted as building code requirements for the communities.

8.

ENVIRONMENTAL IMPACTS

8. ENVIRONMENTAL IMPACTS

8.1 Environmental Setting

The Cochrane River, due to the large natural storage area provided upstream by Wollaston Lake is characteristic of a northern river with limited flow variability. Generally, the river has stablized, well defined shorelines with limited evidence of erosion. Aquatic or semi-aquatic vegetation is common in backwater areas downstream of islands, and in shallow areas within the river. At the time of the visit, water clarity was excellent and there was little evidence of a significant sediment load at any time of the year.

Primary fish species in the river system include whitefish, walleye (pickerel), northern pike (jackfish), lake trout, arctic grayling, and suckers. No commercial fishing takes place along the river at this time. Commercial fishing last occurred in approximately 1975 in Easton Lake and the harvest was significantly less than the quota established. The Manitoba Department of Natural Resources (MDNR) attempts to discourage commercial operations on the river due to the potential for development of a recreational fishery.

Some limited recreational fishing occurs along the river by natives and a very few tourists. Three or four tourists were seen in the summer of 1983.

No documentation is available for the use of the river by spawning lake-run fish from Reindeer Lake. It was suggested that arctic grayling, walleye and whitefish probably utilize the area below the first major rapids, however their movement beyond is uncertain.

The river is used as the primary transportation corridor between Brochet and Lac Brochet, points along the way, and destinations beyond. Several elaborate wooden portage structures were observed at significant whitewater areas along the river.

Reindeer Lake supports a significant commercial fishery. Primary commercial species include whitefish, walleye and lake trout. Other species also present include northern pike, arctic grayling, and suckers. During the summer of 1983, 24 commercial licenses were issued. Total lake harvest quota was set at 203,200 kg of walleye, whitefish and lake trout; which included a maximum lake trout component of 68,100 kg. Approximately eight men from the community of Brochet participated in 1983's commercial harvest. Commercial fishing on Reindeer Lake occurs during the summer season of July 1 - October 30. All commercial fishing camps on the lake are operated from the Saskatchewan side of the lake.

A limited amount of recreational fishing for tourists is catered to by fishing camps at more southerly locations on Reindeer Lake. Some of the residents of Brochet hope to establish a fishing camp for tourists in the near future.

Little information for the aquatic resources of Lac Brochet was obtainable. Species present are expected to be similar to those previously mentioned. Commercial fishing is sporadic but primarily occurs during the winter season: November 1 - April 15. Five inch mesh gill nets are standard for all commercial fishing in this part of the province.

The terrestrial habitat of the area can be described as an open sub-artic woodland dominated by spruce. Other less common tree species include white birch, jackpine, tamarack and popular.

Significant areas of the terrain are dominated by areas of discontinuous permafrost, muskeg and bogs while upland areas have substantial acreages covered by lichen. Along the waterways, willow and other shrubs are common. Large areas (thousands of hectares) of forest adjacent to the Cochrane River have been destroyed in the last few years as a result of fire.

The large game species include moose, black bear and wolves. Barrenland caribou normally remain significantly north of Lac Brochet, however during severe winters they have migrated as far south as Easton Lake. The most recent occurrence of caribou in this section of the Cochrane River was three or four years ago. During mild winters, the barrenland caribou will not move as far south as the province of Manitoba. Moose is the dominant big game species hunted by the residents of Brochet for subsistence purposes.

Small game hunting by the residents includes ptarmigan, spruce grouse, and waterfowl.

A significant amount of commercial trapping is carried out by inhabitants of Brochet. The area between Brochet and Lac Brochet is subdivided into four separate sections. Pursuant to discussions with Mr. Bighetty, the local conservation officer in Brochet, it was learned that 25 men from the community are working traplines in these four areas this winter. The Cochrane River is used as a transportation corridor, however no trapping takes place along the river proper. The primary species of interest are marten and fox. Additional species include otter, mink, wolf and snowshoe hare. This area is beyond the northern-most range of the beaver and muskrat. The unofficial trapping season for the inhabitants of Brochet is divided into two components. The first begins in late

September or early October and extends until Christmas. If the weather is not too severe, the trappers will go out again in the beginning of January until spring.

A few of the larger non-game bird species observed or known to occur in the area include bald eagle, osprey and arctic loon.

8.2 Generic Concerns

Although the following generic environmental concerns are well documented in the literature, the concerns common to all sites considered will be briefly discussed to provide a background for site-specific assessments.

One of the more significant aquatic impacts associated with any of the projects being considered may involve the potential blockage of any upstream migrational routes or degradation of spawning and feeding areas below rapids. However, no documentation of these uses on the Cochrane River is available, so a further assessment of the potential problem at this time is not possible.

The development of borrow areas should attempt to limit the surface acreage disturbed and the potential for subsequent erosion and siltation of adjacent waterways. Access road and transmission corridor development should attempt to avoid waterways including rivers, lakes, streams, ponds, and muskegs when possible to minimize disruptions to normal drainage patterns. In addition, the potential for leakage and/or spillage of petroleum products and other toxic substances will be a concern during construction procedures.

All facilities considered would be operated in a run-of-river mode. As such, impacts associated with wide fluctuations to

impoundment water levels and downstream flows will not occur.

It appears that relatively small impoundments of water will be required for most of the proposed schemes and consequently only minor water quality impacts are foreseen. The more significant of these will include the potential for slumpage of shoreline areas, especially in areas of permafrost, causing increased turbidity and siltation in the watershed. As well, small increases in total dissolved solids, nutrients and possibly toxic metals such as mercury may be realized as a result of leaching due to inundation of soils within the impoundment.

Immediate downstream areas (rapids) will realize some limited dewatering as a result of passage of water through the powerhouse. Reaeration of the water as it cascades down the rapids will be diminished but should not prove significant given the climate and the lack of industrial or municipal wastes requiring assimilation. Some limited erosion could occur downstream of any project discharge as a result of the reorientation of the river flow. Consequently, stabilization of shorelines in some areas may be necessary.

The most significant impacts to terrestrial habitats and inhabitants will probably result from the construction of access roads and transmission corridors. Both access road and transmission corridor development will necessitate the loss of habitat through clearing of vegetation and subsequent filling. The extent of losses will depend upon the width of the right-of-ways associated with the transmission lines and access roads. Winter construction employing ice roads should be used when possible. Access roads and diversion schemes can prove to be wildlife migration barriers if improperly designed. Although winter caribou migrations are not common in the area under

consideration, occasional severe weather does bring them down into the vicinity of some of the sites being considered. Though not likely, transmission lines could also prove to be troublesome to caribou movement, if constructed too close to the ground.

Transmission towers are a favorite nesting location for osprey, and could be used by other raptors such as eagles for perching locations. Consequently, design should attempt to minimize the potential for electrocution by providing sufficient distance between lines or possibly orienting lines vertically along the pole to preclude simultaneous wing contact with two wires.

NDNR has indicated the transmission corridor should be developed away from the river wherever possible to minimize any aesthetic impacts for present or future recreational users of the river.

In contrast to the above problems, benefits would probably result from access road and transmission corridor development by providing overland transportation routes for the residents of the area.

8.3 Hydro Site Observations

The following section presents environmental observations of three major sites considered - Axes L-3, L-4 and the Diversion Scheme.

Axis L-3

Site L-3, the lower-most set of rapids on the Cochrane River, appears to have the least potential for significant environmental impacts. Given the proposed run-of-river scheme involving a 2 - 3 metre high impoundment just above the falls, water would be backed up approximately 1,500 - 2,000 m in the upstream direction to the next set of rapids. Flooding of shoreline areas would involve lateral distances of generally anywhere between 10 and 200 metres. One narrow low-lying area immediately to the west of the proposed facility may experience some extended flooding up to an estimated 300 m. However, most of the proposed impoundment area has fairly well stabilized banks. Some additional wetland areas associated with the impoundment will also be inundated.

One of the primary impact potentials associated with this location will be the possibility of prohibiting the movement of fish from Reindeer Lake up the river for the purpose of spawning. In addition, it is quite likely the area immediately below the rapids is used for spawning and feeding. However, as was previously mentioned, no documentation of these occurrences are available and as a consequence a survey may be necessary to determine the existence of any possible movements and/or use of the area by the fisheries of Reindeer Lake.

Access to this site would be the best of all the sites considered. It is located in closest proximity to the Town of Brochet, a distance of approximately eight miles. A rough trail already proceeds from the town for approximately two miles in the direction of the site.

A transmission corridor to the Town of Brochet would be equally short and could follow the same corridor to minimize the need for a second access corridor. One of the primary drawbacks of the site would be the lengthy transmission route (80 kilometers) necessary to reach the community of Lac Brochet. Numerous water bodies would have to be avoided including lakes, ponds, bogs and muskegs. A crossing of the Cochrane River would also be needed. However, lengthy transmission corridors with similar problems will result from any single development on the river.

In summary, Site L-3 is acceptable given the proposed run-of-river scheme involving limited flooding, only partial use of total river flow, minimal dewatered areas and its proximity to the community of Brochet. The major drawbacks will entail a possible obstruction to any upstream movement of fish and the lengthy transmission line needed to reach Lac Brochet.

Axis L-4

A second site visited on the lower river, L-4, was located approximately 1,500 to 2,000 m upstream of Site L-3. Development of this site would require a dam of approximately 3 - 4 m in height with a diversion route involving a spillway across an adjacent peninsula which would discharge into a small backwater wetland area and secondary downstream channel. Once again this facility would be operated in a run-of-river mode using only a portion of the total river flow under normal conditions.

Given its proximity to Brochet, access and transmission impacts would be similar to Site L-3.

The closure of a dam of 3 - 4 m in height would probably impound water for a significant distance upstream. The next set of rapids, approximately 1,500 - 2,000 m upstream, appeared from the air to have less than a metre in head. This would allow inundation to proceed further upstream as no additional rapids were in evidence for miles upstream. As such, substantial impacts associated with the inundation of shoreline, especially to areas of permafrost, would be expected.

Downstream from the dam, an approximate 100 m of river would be dewatered. The proposed development of this 4 - 5 m dam would preclude any upstream movement of resident fish populations.

Downstream from the discharge, a secondary river channel would receive a considerably increased flow, and subsequent erosion impacts could occur. Further study and field surveys would be required to determine the extent of this.

Diversion Scheme

While there is an attractive 10 to 12 m of head afforded by this scheme, it should be noted that the diversion of water for a distance of some 35 km in a direction at times contrary to the existing natural flow patterns would not be the most environmentally attractive scheme considered. This aspect would require detailed survey and study to identify impacts which may arise. On the other hand, very little flooding would be involved since the impoundment from a rockfill groin at Kamacheechawasik Rapids would raise water levels only some 1 to 2 metres.

8.4 Environmental Impact of Transmission Lines

The main impact from the construction and operation of transmission lines, either from a hydro site on the Cochrane or from a Manitoba Hydro grid at Lynn Lake, would result from the cleared right-of-way from the line. The impacts would include:

- the aesthetic impact that results from such clearing of natural timberlands.

- the reduction of trapping potential during the construction period when many of the fur-bearers would likely leave that area.

- better access along the transmission corridor to ungulates such as moose may result in greater hunting pressure on the species.

- the right-of-way would provide access to previously inaccessible merchantable timber stands or sources of firewood.

- an impact to archaeological resources may occur and line routing would have to consider known sites which could be located by an archaeologist.

9.

FINANCIAL ANALYSIS OF ENERGY ALTERNATIVES

9. FINANCIAL ANALYSIS OF ENERGY ALTERNATIVES

The preceeding analysis has identified that four broad energy supply categories are realistically available to the two study communities:

1. Continued Diesel Generation (15 amp., no electric heat)
2. Hydroelectric Generation - Intermediate Load (100 amp. no electric heat)
3. Hydroelectric Generation - High Load (100 amp. with electric heat)
4. Transmission Line from Lynn Lake - both Intermediate and High Load

The ensuing financial analysis encompasses the various electrical energy alternatives associated with the two communities, both separately and combined. In conjunction with the identified electrical energy alternatives, the financial analysis also includes those other energy sources such as oil, wood/gasoline and propane which are required for community existence and will be affected by proposed electrical energy development. Diesel generation costs were projected separately for each community so as to illustrate present electrical generation practice. The cost of diesel generation to meet intermediate/high load needs would be prohibitively high and was not included in this analysis. Similarly, the cost of hydroelectric generation to meet low load requirements is prohibitively high and was not included in this analysis. Hydroelectric intermediate load case is presented with the electrical needs of the two communities satisfied with one development, and the needs of each community satisfied with separate developments. Hydroelectric full load case is presented as one development satisfying both communities as separate developments in this instance are not economical. Transmission line development is

presented for both intermediate/full load cases, and, for Brochet/Lac Brochet combined and Brochet only. A transmission line to Lac Brochet alone is unrealistic and was not analyzed.

All capital costs were estimated to provide developments capable of satisfying the load forecasts as presented earlier in this report. The associated operation, maintenance and energy costs were also based directly upon the aforementioned load forecasts and reflect actual costs to Manitoba Hydro in the case of both the diesel and transmission line alteratives. Hydroelectric energy costs are included in overhead and maintenance estimates.

The various alternatives are compared on the basis of the net present value of their capital and related annual costs covering the period 1985 to the year 2009. The year 1985 was assumed to be the first full year in which development of the various alternatives could begin. As the community growth projections developed in this report end in the year 2008, the resultant 25 year analysis period accounts for such growth. While actual construction initiation dates may vary, the resultant analysis does allow accurate comparison.

Growth in the study region is viewed as being fairly consistent on an annual basis. The anticipated increases in electrical demand, when considering supply enhancement from existing 15 amp. service to either intermediate 100 amp. (no electric heat) or high load 100 amp. (electric heat) are not uniform over the 25 year analysis period. Such non-uniform increases do not readily lend themselves to financial analysis based upon constant dollar assumptions. For purposes of this analysis, it was therefore decided to project forward all associated costs at a rate of inflation of 8% and discount these values back to 1984 dollars at 12%. The net result is a present value analysis utilizing a discount factor of 4%.

For purposes of this analysis, hydroelectric generation was assumed to have a useful life of 67 years while a transmission line was assumed to comprise 40 years. Diesel life at Brochet and Lac Brochet was assumed at 15 years and 20 years respectively.

The accompanying cash flow statements presented in table 9-1 form the basis of the ensuing present value financial analysis.

The capital cost of the various energy alternatives was amortized taking into account probable methods of financing these developments over their useful economic life periods. The cost of capital is converted into an annual charge and the present value of these flows then calculated for the planning period considered. This approach implies that the resulting cash flows continue ad infinitum and that each facility will be replaced at the end of its economic life by an equivalent facility at identical cost. The economic life adjustment is therefore reflected in the longer amortization period associated with developments comprising a larger economic life.

The total capital cost of the diesels was amortized over 25 years at an interest rate of 12%.

The total capital costs of the hydroelectric alternatives were amortized and determined as follows:

Hydroelectric - Capital Cost x .1201 (amort. 67 yrs. @ 12%) x 7.843(p.v. of flows discounted at 12%)

Transmission line capital costs were similarly determined as follows:

T.Line Capital Cost x .1213 (amort. 40 yrs. @ 12%) x 7.843 (p.v. of flows discounted at 12%).

9.1 Continued Diesel Generation - Low Load

This first energy scenario assumes that diesels will continue to be utilized to provide electrical energy to the study area at low load levels. As a result, the communities will also continue to rely on wood/gasoline for residential heating and cooking, oil for institutional heating and propane for selected cooking and other uses.

The total present value costs of satisfying the communities' energy needs with existing facilities and systems is presented in table 9-2:

Present Value Energy Costs (1984 dollars)
Brochet & Lac Brochet
Continued Diesel Generation - Low Load — Table 9-2
Inflation 8%, P.V. Discount 12%
Projection Period 1985 - 2009

(000's)	Amortized Cap. Cost	O/M	Energy Cost	Total Cost
Brochet:				
Diesel Generation	840	4,617	included in O/M	5,457
Wood/Gasoline			3,202	3,202
Oil			3,280	3,280
Propane			31	31
Total Cost	840	4,617	6,513	11,970
Lac Brochet:				
Diesel Generation	330	5,386	included in O/M	5,716
Wood/Gasoline			1,564	1,564
Oil			1,657	1,657
Propane			171	171
Total Cost	330	5,386	3,392	9,108
Total Cost for both communities				21,078

Amortized capital costs are based upon Manitoba Hydro's estimates for diesel unit replacement/addition over planning

period. Operation and maintenance costs (including energy) reflect Manitoba Hydro's actual cost of operation, which is currently higher than revenue generated in the study area.

9.2 Hydroelectric - Intermediate Load

Intermediate load, 100 amp. service, would enable the study communities to utilize electricity for cooking and other similar uses. As a result, propane would no longer be required as electricity would provide major appliance services. Wood/gasoline and oil useage would not be altered significantly.

Present Value Energy Costs (1984 dollars)
Hydroelectric - Intermediate Load
Inflation 8%, P.V. Discount 12%
Projection Period 1985 - 2009

Table 9-3

(000's)	Amortized Cap. Cost	O/M	Energy Cost	Total Cost
Brochet & Lac Brochet:				
Hydroelectric	14,610	3,463	Included in O/M	18,073
Wood/Gasoline			4,766	4,766
Oil			4,937	4,937
Propane			nil	-0-
Total Cost	14,610	3,463	9,703	27,776
Brochet Only:				
Hydroelectric	9,580	2,219	Included in O/M	11,799
Wood/Gasoline			3,202	3,202
Oil			3,280	3,280
Propane			nil	-0-
	9,580	2,219	6,482	18,281
Lac Brochet Only:				
Hydroelectric	8,443	1,955	Included in O/M	10,398
Wood/Gasoline			1,564	1,564
Oil			1,657	1,657
Propane			nil	-0-
	8,443	1,955	3,221	13,619

The initial hydroelectric alternative illustrates the present value costs associated with establishing one hydro development to service both communities. The remaining alternative illustrates the present value costs associated with developing separate and smaller hydroelectric facilities for each community.

9.3 Hydroelectric - High Load

Full load electrical service would enable the study communities to satisfy all heating, cooking and other energy needs with electricity. Consequently, oil and propane would no longer be required. It was assumed that 20% of existing wood/gasoline useage would account for those not willing or able to convert to electric heat, and would reflect some wood/gasoline back-up capability in the event of electrical heating failure.

Separate hydroelectric development for Brochet and Lac Brochet high load cases would be uneconomical and were not presented in this analysis.

Present Value Energy Costs (1984 dollars)
Hydroelectric - High Load
Inflation 8%, P.V. Discount 12%
Projection Period 1985 - 2009

Table 9-4

(000's)	Amortized Cap. Cost	O/M	Energy Cost	Total Cost
Brochet & Lac Brochet:				
Hydroelectric	23,144	3,414	Included in O/M	26,558
Wood/Gasoline			953	953
Oil, Propane			-0-	-0-
Total Cost	23,144	3,414	953	27,511

9.4 Transmission Line - Intermediate & High Loads

A potential transmission line connection from Lynn Lake to the study communities was determined to be a viable electrical energy supply alternative. The capital, operating and energy costs for both intermediate and high load cases are illustrated in the accompanying Table 9-5.

Present Value Energy Costs (1984 dollars)
Brochet and Lac Brochet - Transmission Line
Intermediate and High Load
Inflation 8%, P.V. Discount 12% Table 9-5
Projection Period 1985 - 2009

(000's)	Amortized Cap. Cost	O/M	Energy Cost	Total Cost
Brochet & Lac Brochet:				
Intermediate Load	11,839	1,918	1,214	14,971
Wood/Gasoline			4,766	4,766
Oil			4,937	4,937
Propane			-0-	-0-
Total	11,839	1,918	10,917	24,674
Brochet & Lac Brochet:				
High Load	11,839	1,918	2,483	16,240
Wood/Gasoline			953	953
Oil, Propane			-0-	-0-
Total	11,839	1,918	3,436	17,193
Brochet Only:				
Intermediate Load	6,919	1,170	772	8,861
Wood/Gasoline			3,202	3,202
Oil			3,280	3,280
Propane			-0-	-0-
	6,919	1,170	7,254	15,343
Brochet Only:				
High Load	6,919	1,170	1,645	9,734
Wood/Gasoline			640	640
Oil, Propane			-0-	-0-
	6,919	1,170	2,285	10,374

The unit cost of electric energy via transmission from Lynn Lake was initially set at 1.74¢/kWh (early 1984) as per discussions with Manitoba Hydro. This unit cost was also escalated by 8% per annum.

The above table represents four (4) alternate transmission line hook-up possibilities. The line could run to both study communities under high or intermediate load assumptions. The line could also run to Brochet only under high or intermediate load assumptions, whereupon Lac Brochet would be responsible for its own electrical energy procurement either via existing diesels or a separate low head hydro development.

9.5 Financial Analysis - Summary and Conclusions

The total costs presented in the various energy alternatives are presented in table 9-6 below:

Present Value Energy Costs (1984 dollars)
Brochet and Lac Brochet
Inflation 8%, P.V. Discount 12%
Projection Period 1985 - 2009

Table 9-6

(000's)	Amortized Cap. Cost	O/M	Energy Cost	Total Cost
Continued Diesel - Low Load:				
Brochet (including oil, propane, wood/gas)	840	4,617	6,513	11,970
Lac Brochet (including oil, propane, wood/gas)	330	5,386	3,392	9,108
Total	1,170	10,003	9,905	21,078
Hydroelectric - Intermediate:				
Brochet - Lac Brochet (including wood/gas, oil)	14,610	3,463	9,703	27,776
Brochet Only (including wood/gas, oil)	9,580	2,219	6,482	18,281
Lac Brochet Only (including wood/gas, oil)	8,443	1,955	3,221	13,619
Hydroelectric - High:				
Brochet & Lac Brochet (including wood/gas)	23,144	3,414	953	27,511
Transmission Line:				
Brochet & Lac Brochet - Intermediate (including wood/gas, oil)	11,839	1,918	10,917	24,674
Brochet & Lac Brochet - High (including wood/gas)	11,839	1,918	3,436	17,193
Brochet Only - Intermediate (including wood/gas, oil)	6,919	1,170	7,254	15,343
Brochet Only - High (including wood/gas)	6,919	1,170	2,285	10,374

The most economical source of energy to the communities, from an overall energy system viewpoint, is a high load transmisson line hook-up to the Manitoba grid. High load (electric heat) will enable the study communities to virtually eliminate costly heating oil and wood/gasoline consumption at an overall cost which is much cheaper than the present energy system or a hydroelectric development. Transmission line (from Lynn Lake) construction costs are the most economical of any of the enhanced electrical energy alternatives and therefore contribute significantly to the overall energy cost reduction.

Hydroelectric alternatives comprise the greatest capital cost of any of the enhanced electrical energy alternatives. Hydroelectric development also entails the most economical O/M and energy costs of the enhanced electrical supply alternatives.It is therefore observed that the high capital cost of hydroelectric development places this alternative in the highest overall cost category of enhanced energy alternatives.

Diesel generation is the most costly of all the energy alternatives considered. While diesel generation comprises the least capital cost, limited diesel generated electricity and associated wood/gas/oil requirements also comprise the highest O/M and energy costs which enable reduced 15 amp. diesel generation to be compared to the other alternatives from a cost effectiveness viewpoint. Limited 15 amp. diesel service with related wood/gas/oil resources will cost the study communities approximately $155 k ($1984) per year more, for the next 25 years, than installing a transmission line from Lynn Lake and providing electric heat.

Any other combination of transmission line to Brochet only and a separate hydroelectric development for Lac Brochet would be more costly, from a total energy supply viewpoint, than a transmission line connection to both communities.

Energy Demonstration Study
Cash Flow Projections - 8% Inflation Rate
Assume All Start-Ups 1985

Table 9-1 A

Diesel Generation [1] Low Land	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Brochet:													
Value of Existing Units	317,600	294,800									350,000		
Unit Addition				323,000									
Oper. & Maint.	182,800	204,770	228,110	254,520	282,880	312,815	344,895	381,415	420,320	463,600	548,640	644,950	751,970
Lac Brochet:													
Value of Existing Units	236,900	220,000											
Unit Addition													
Oper. & Maint.	153,900	191,730	234,355	282,842	335,870	374,530	417,690	465,040	517,360	577,435	666,240	765,645	876,510
Hydroelectric Intermediate 100 Amp. [2]													
Brochet & Lac Brochet:													
Installed Cost		2,340,000	2,528,000	10,917,000				4,456,000				563,000	608,000
Oper. & Maint.					268,300	289,800	313,000	413,800	446,900	482,700	521,300		
Brochet Only:												5,830,000	
Installed Cost		1,674,000	1,808,000	7,810,000									
Oper. & Maint.					192,000	207,400	223,900	241,800	261,200	282,000	304,600	428,100	462,300
Lac Brochet Only:												5,130,000	
Installed Cost		1,476,000	1,594,000	6,885,000									
Oper. & Maint.					169,200	182,700	197,400	213,100	230,200	248,600	268,500	377,200	407,400
Hydroelectric High Land - 100 amp. elec. heat													
Brochet & Lac Brochet:													
Installed Cost		4,320,000	4,666,000	20,155,000							8,204,000		
Oper. & Maint.					495,400	535,000	577,800	624,100	674,000	727,900	925,600	999,600	1,080,000

Assume All Start-Ups 1985

Table 9-1.8

Diesel Generation [1] Low Load	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brochet:													
Value of Existing Units						1,296,000							1,110,000
Unit Addition						1,491,200	1,638,840	1,811,810	2,002,925	2,210,960	2,442,825	2,694,500	2,911,250
Oper. & Maint.	872,050	1,007,300	1,111,400	1,226,150	1,351,980								
Lac Brochet:													
Value of Existing Units								1,320,000					
Unit Addition								2,150,380	2,384,760	2,644,590	2,929,050	3,236,305	3,494,700
Oper. & Maint.	1,000,295	1,137,050	1,267,540	1,411,605	1,570,825	1,747,790	1,936,480						
Hydroelectric Intermediate 100 Amp. [2]													
Brochet & Lac Brochet:													
Installed Cost	7,072,000												
Oper. & Maint.	776,800	838,900	906,000	978,500	1,057,000	1,141,000	1,233,000	1,438,000	1,553,000	1,677,000	1,811,000	1,956,000	2,112,000
Brochet Only:													
Installed Cost													
Oper. & Maint.	499,300	539,600	582,600	629,000	679,300	733,700	792,400	855,800	924,200	998,200	1,078,000	1,164,000	1,257,000
Lac Brochet Only:													
Installed Cost													
440,000 Maint.	440,000	475,200	513,200	554,200	598,600	646,500	698,200	754,000	814,300	879,500	949,900	1,026,000	1,108,000
Hydroelectric High Load - 100 amp. elec. heat [2]													
Brochet & Lac Brochet:													
Installed Cost													
Oper. & Maint.	1,164,000	1,259,000	1,360,000	1,469,000	1,586,000	1,713,000	1,850,000	1,998,000	2,158,000	2,331,000	2,517,000	2,719,000	2,936,000

Assume All Start-Ups 1985

Table 9-1 C

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Transmission Line/Lynn Lake [3]													
Intermediate Load													
Brochet and Lac Brochet:													
Installed Cost		7,096,000	7,663,000										
Operation & Main.				177,100	191,300	206,600	223,100	240,900	260,200	281,000	303,500	327,800	354,000
Energy Cost - MWH				1,156	1,677	2,198	2,719	3,240	3,761	4,280	4,578	4,876	5,174
- mj/Kwh				2.19	2.37	2.55	2.76	2.98	3.22	3.48	3.75	4.05	4.38
- $				25,300	39,700	56,000	75,000	96,600	121,100	148,900	171,700	197,500	226,600
Brochet Only:													
Installed Cost		4,147,000	4,479,000										
Operation & Main.				103,500	111,800	120,700	130,400	140,800	152,100	164,200	177,400	191,600	206,900
Energy Cost - Mwh				886	1,192	1,498	1,804	2,110	2,416	2,721	2,928	3,135	3,342
- mj/Kwh = $				19,400	28,300	38,200	49,800	62,900	77,800	94,700	109,800	127,000	146,400
Transmission Line/Lynn Lake [3]													
High Load													
Brochet & Lac Brochet:													
Installed Cost		7,096,000	7,663,000										
Operation & Maint.				177,100	191,300	206,600	223,100	240,900	260,200	281,000	303,500	327,800	354,000
Energy Cost - Mwh				1,156	2,532	3,908	5,382	6,660	8,037	9,410	10,158	10,906	11,654
- mj/Kwh = $				25,300	60,000	99,700	145,800	198,500	258,800	327,500	380,900	441,700	510,400
Brochet Only:													
Installed Cost		4,147,000	4,479,000										
Oper. & Maint.				103,500	111,800	120,700	130,400	140,800	152,100	164,200	177,400	191,600	206,900
Energy Cost - Mwh				886	1,698	2,510	3,322	4,134	4,946	5,759	6,320	6,881	7,442
- mj/Kwh = $				19,400	40,200	64,000	91,700	123,200	159,300	200,400	237,000	278,700	326,000
Other Energy [4]													
Wood/Gasoline													
Brochet:	125,000	140,300	157,400	176,600	198,100	222,300	249,400	279,800	313,900	352,200	395,200	443,400	497,500
Lac Brochet:	66,200	75,700	82,000	91,300	101,600	113,100	125,800	140,100	155,900	173,500	193,100	214,900	239,200

Assume All Start-Ups 1985

Table 9-1 D

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Transmission Line/Lynn Lake [3]													
Intermediate Load													
Brochet and Lac Brochet:													
Installed Cost													
Operation & Main.	382,300	412,900	446,000	481,600	520,200	561,800	606,700	655,300	707,700	764,300	825,500	891,500	962,800
Energy Cost - Mwh	5,672	6,773	6,069	6,365	6,661	6,957	7,253	7,361	7,469	7,577	7,685	7,793	7,793
- mj/Kwh	4.73	5.11	4.41	4.96	6.43	6.95	7.50	8.10	8.75	9.45	10.20	11.02	11.91
- $	250,800	295,000	344,600	379,600	428,300	483,500	544,000	596,200	653,500	716,000	783,900	858,800	928,100
Brochet Only:													
Installed Cost													
Operation & Main.	223,400	241,300	260,600	281,500	304,000	328,300	354,600	383,000	413,600	446,700	482,400	521,000	562,700
Energy Cost - Mwh	3,549	3,757	3,867	3,977	4,087	4,197	4,307	4,446	4,585	4,724	4,863	4,000	5,000
- mj/Kwh = $	167,900	192,000	213,100	237,100	262,800	291,700	323,000	360,100	401,200	446,400	496,000	551,000	595,500
Transmission Line/Lynn Lake [3]													
High Load													
Brochet & Lac Brochet:													
Installed Cost													
Operation & Maint.	382,300	412,900	446,000	481,600	520,200	561,800	606,700	655,300	707,700	764,300	825,500	891,500	962,800
Energy Cost - Mwh	12,402	13,149	13,533	13,917	14,301	14,685	15,067	15,562	16,057	16,552	17,047	17,540	17,540
- mj/Kwh = $	586,600	671,000	745,600	829,500	919,500	1,021,000	1,130,000	1,261,000	1,405,000	1,564,000	1,739,000	1,933,000	2,089,000
Brochet Only:													
Installed Cost													
Operation & Maint.	223,400	241,300	260,600	281,500	304,000	328,300	354,600	383,000	413,600	446,700	482,400	521,000	562,700
Energy Cost - Mwh	8,003	3,566	3,760	8,914	9,088	9,262	9,436	9,783	10,130	10,477	10,824	11,172	11,172
- mj/Kwh = $	370,500	457,700	481,600	531,300	584,400	643,700	707,700	792,400	886,400	990,100	1,104,000	1,231,000	1,331,000
Other Energy [4]													
Wood/Gasoline													
Brochet:	558,200	626,300	702,800	788,500	884,700	992,600	1,114,000	1,250,000	1,402,000	1,573,000	1,765,000	1,980,000	2,222,000
Lac Brochet:	266,300	296,300	329,800	367,100	408,600	454,700	506,100	563,300	627,000	698,000	776,700	864,500	962,100

Table 9-1 f

Assume All Start-Ups 1985

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Other Energy - Con't													
Oil													
Brochet (L)	303,464	303,464	303,464	303,464	303,464	303,464	303,464	303,464	303,464	303,464	330,134	356,804	383,424
x price ¢/L	59.9¢	60.6	65.2	70.4	76.1	82.1	88.7	95.8	$1.03	1.18	1.21	1.30	1.41
Total $	$168,635	183,290	197,860	213,640	230,935	249,145	269,170	290,720	312,565	358,085	399,460	463,845	540,630
Lac Brochet (L)	76,910	88,215	99,520	110,825	122,120	122,120	122,120	122,120	122,120	124,120	137,295	150,470	163,645
x price ¢/L	67.5¢	72.9	78.7	85.0	91.8	99.2	$1.07	1.16	1.25	1.35	1.46	1.57	1.70
Total $	$51,915	64,330	78,325	94,200	112,105	121,145	130,670	141,660	152,650	167,450	200,450	236,240	278,195
Propane													
Brochet (Kg)	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,680	3,170	2,660
x price ¢/Kg	65.0¢	70.2	75.8	81.9	88.4	95.5	$1.03	1.14	1.20	1.30	1.40	1.52	1.64
Total $	$1,428	1,540	1,660	1,795	1,936	2,090	2,255	2,495	2,628	2,847	3,752	4,818	4,000
Lac Brochet (Kg)	3,374	3,681	3,988	4,295	4,605	4,605	4,605	4,605	4,605	4,605	4,952	5,299	5,646
x price/Kg	$2.20	2.38	2.57	2.77	2.99	3.23	3.49	3.77	4.07	4.40	4.75	5.13	5.54
Total $	$7,425	8,760	10,250	11,895	13,770	14,875	16,070	17,360	18,740	20,265	23,522	27,185	31,280

Assume All Start-Ups 1985

Table 9-1 F

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Other Energy - Con't													
Oil													
Brochet (L)	410,144	436,800	436,800	436,800	436,800	436,800	436,800	436,800	436,800	436,800	436,800	436,800	436,800
x price/L	1.52	1.64	1.77	1.92	2.07	2.23	2.41	2.61	2.82	3.04	3.28	3.54	3.83
Total $	623,420	716,350	773,135	838,655	904,175	974,065	1,052,790	1,140,050	1,231,775	1,327,870	1,432,705	1,546,270	1,672,945
Lac Brochet (L)	176,820	190,000	190,000	190,000	190,000	190,000	192,000	192,000	192,000	192,000	192,000	194,000	194,000
x price/L	$1.84	1.98	2.14	2.31	2.50	2.70	2.91	3.15	3.40	3.67	3.96	4.28	4.62
Total $	$325,350	376,200	406,600	438,900	475,000	513,000	558,720	604,800	652,800	704,640	760,320	830,320	896,280
Propane													
Brochet (Kg)	4,150	4,630	4,630	4,630	4,640	4,630	4,630	4,630	4,630	4,630	4,630	4,630	4,630
x price/Kg	1.77	1.91	2.06	2.23	2.41	2.59	2.81	3.03	3.27	3.53	3.82	4.12	4.45
Total $	$7,345	8,845	9,540	10,325	11,160	11,990	13,010	14,030	15,140	16,345	17,685	19,075	20,605
Lac Brochet (Kg)	5,993	6,340	7,340	6,340	6,340	6,340	6,340	6,340	6,340	6,340	6,340	6,340	6,340
x price/Kg	5.98	6.46	6.98	7.53	8.14	8.79	9.49	10.25	11.07	11.96	12.92	13.95	15.06
Total $	$35,840	40,955	44,255	47,740	51,610	55,730	60,165	64,985	70,185	75,825	81,910	88,445	95,480

Notes to Cash Flow Statements - Table 9-1

Note 1. **Diesel**

Brochet:

The book value of existing assets was determined by multiplying depreciation charged in 1982/83 by 15 as Manitoba Hydro depreciates its diesels over 15 years on a straight line basis. A yearly depreciation charge was then deducted in 1984 and 1985 to arrive at a net book value for 1985. This net book value identifies existing investment in diesels and is incorporated to diesel capital cost estimates.

Diesel unit additions were based upon growth estimates and discussions with Manitoba Hydro. Initial estimates of $500/kw installed costs were inflated at 8% per annum as required:

	Year	Existing and Forecast Demand (kW)	Existing Diesel Capacity (kW)	New Diesels Installed (kW)	Retired Diesel Capacity (kW)	Total Diesel Capacity (kW)	Inflated Installed Cost ($)
Brochet							
	1984[1]	220	650	-0-	-0-	650	
	1987[2]	240	300	350	350	650	$ 323,000
	1994[3]	300	350	300	300	650	349,500
	2002[4]	440	300	600	350	900	1,296,000
	2009[5]	500	600	300	300	900	1,110,000
Lac Brochet							
	1984[6]	80	525	-0-	-0-	525	
	2004[7]	230	-0-	525	525	525	$1,320,000

Notes: 1) Existing diesels at Brochet consist of 2 @ 175 kW (3 years life remaining) and 1 @ 300 kW (10 years life remaining).
2) 2 @ 175 kW replaced with 2 new diesels @ 175 kW.
3) 1 @ 300 kW replaced with 1 @ 300 kW.
4) 2 @ 175 kW replaced with 2 @ 300 kW.
5) 1 @ 300 kW replaced with 1 @ 300 kW.
6) Existing diesels at Lac Brochet
7) 3 @ 175 kW replaced with 3 @ 175 kW

Operation and maintenance estimates were projected by examining available Manitoba Hydro records to 1982/83 regarding direct operation. Direct operating costs, excluding depreciation and interest (in order to retain consistency with the analysis of other alternatives) were then projected to increase by 8% per annum plus additional percentage increases for anticipated increases in demand due to population growth and community development.

A major component of direct generation cost is fuel, especially when considering transportation to the study area. The 8% per annum projected increase was applied to all direct operating cost categories.

Lac Brochet

Lac Brochet existing asset values and operations projections were determined in a similar manner as presented for Brochet.

Diesel unit additions were estimated as follows:

1984 3 diesels @ 175 kw - 20 yrs. life remaining

2004 3 diesels @ 175 kw - to replace 1984
525 kw @ $500 x 5.03 = $1,320 K

Lac Brochet Diesels were estimated to have an economic life of approximately 20 years as opposed to 15 years for Brochet. This is due to the anticipated smaller loads at Lac Brochet which should be adequately handled by the 175 kw generator units with less strain. The 15-20 year life

span of diesels utilized in this report is consistent with current industry averages and Manitoba Hydro depreciation factors.

Note 2: **Hydroelectric - Intermediate 100 amp.**

Brochet and Lac Brochet Axis L-3

Construction scheduling was estimated at 17% of capital cost in Year 1, 17% in Year 2 and the remainder in Year 3. Costs were inflated by 8% per year to account for current economic conditions. Expansions to the initial development were also inflated at 8% per annum.

Yearly operations and maintenance costs, including energy, were estimated at 1.7% of inflated capital costs. Those estimates were then increased by 8% per annum to account for inflation. Operation costs were increased according to development expansion.

Brochet only Axis L-3
Lac Brochet only Axis U-4

Brochet and Lac Brochet - Full load 100 amp. - Axis L-3

These other alternatives were projected in a similar manner as discussed above.

Note 3: **Transmission Line from Lynn Lake**

All Alternatives:

The transmission line was assumed to require 50% of capital costs in Year 1 and the remainder in Year 2. An inflation rate of 8% per annum was applied to capital costs. Yearly operations and maintenance costs (not including energy) were estimated at 1.2% of inflated capital costs. Operating costs were then increased by 8% per annum to account for inflation.

Energy charges were based upon the demand estimates presented earlier in this report. An initial charge of 1.74¢/kwh in early 1984 for energy useage was identified by Manitoba Hydro as the cost of energy at Lynn Lake. This charge was then projected at a rate of 8% per annum and applied to anticipated demand.

Note 4: **Wood Costs for Heating**

The present costs for obtaining wood, oil and propane, have been documented earlier in this report. These costs were projected to account for inflation at 8% and annual population increases assuming present energy supply (diesel) conditions.

10.

SOCIO-ECONOMIC ASSESSMENT

10. SOCIO-ECONOMIC ASSESSMENT

The four major socio-economic impact areas associated with the development alternatives are:

1. Electrical Energy Consumer costs
2. Development Related Employment
3. Lifestyle and Area Developments
4. Environmental Impact

10.1 Electrical Energy Consumer Costs

The accompanying cost summary is based on data presented earlier in this report. It is observed that the cost of diesel energy to the commmunities is significantly greater than the cost anticipated for electrical energy supply and via transmission tie-in to the Manitoba grid system. Moreover, transmission tie-in would also provide the communities with virtually unlimited electrical energy supply as opposed to the highly restricted 15 amp. service now provided by diesel. Should present rates and conditions persits, diesel generation with restricted 15 amp. service is the most expensive energy supply alternative considered in this report.

Energy Cost Comparison
Electricity & Fire Wood ¢/kWh

	Heating		Non-Heating	Electricity
	Electricity	Wood[1]	Residential	Commercial
Present Cost (15 amp. diesel)		3.6¢	7.0¢	35 to 57
High Load[2] (No limitations)	3.7¢		3.7¢	35

1 Assumes 65% efficiency of wood stove & $118/cord including gasoline
2 Assumes transmission tie-in with Manitoba Hydro grid

Continued utilization of 15 amp. diesel generation will require no upgrading for the residences in the study area. However, most residential users in the study area who want to convert to either 100 amp. intermediate load or 100 amp. full load will likely incur costs pertaining to labour, wiring and materials as follows:

	1984 $
- Upgrading from existing 15 amp. service to 100 amp. service including breakers, re-wiring of receptacles, new circuit installation, etc.	$1,000
- Marginal cost to convert upgraded house to electric heat including circuits, main breakers (125 amp) heaters, etc. Every residence already has a 140 amp. service drop which should adequately handle electric heating loads.	$1,000 - $1,500

Most of the residences in the study area, 136 at the time of writing this report, utilize 15 amp. service and would require upgrading in order to take advantage of enhanced electrical service. Most institutions and businesses in the study area now experience unrestricted service and would probably require very little upgrading in order to utilize intermediate load 100 amp. service. All residences, institutions and businesses would require significant upgrading in order to convert to full load, 100 amp. electric heat service.

Diesel Generation Rates

If diesel generation facilities are maintained, existing rates and charges will apply to users as follows:

a) Diesel Residential Rate:
4,000 kWh/yr/households (average consumption)
or 416 kw/hr./month/household

1st 250 kWh @ 5.902¢/kWh	$14.76
Balance 167 kWh @ 2.988¢/kWh	4.99
Service Charge	9.84
TOTAL	$29.19/month

Effective Residential Rate $29.19/417 kWh = 7¢/kWh.

b) Commercial/Institutional Full Cost Rate:

Brochet	35¢/kWh
Lac Brochet	57¢/kWh

As per the load forecasts presented earlier in this report, diesel generation residential users will increase revenue generated to Manitoba Hydro from a total of $40K ($1983) per annum to $130K ($1983) per annum in the year 2008 as created primarily by community growth. Institutional/commercial users revenue to Manitoba Hydro will increase from $265K ($1983) per annum to $572K ($1983) per annnum in 2008.

Transmission Line Rates - Intermediate

Electrical consumption per household will increase for those who convert to intermediate 100 amp. service. As per load projections presented earlier in this report, the increased use of appliances, the acquisition of new appliances (stoves for example) will serve to increase average residential consumption from 5,000 kWh/yr to 13,500 kWh/yr in 2008 assuming intermediate 100 amp power. Assuming grid residential and institutional/commercial rates currently in force would be applied to expanded service customers, the following energy useage costs would apply:

Intermediate 100 amp.

a) Residential Rate:
13,500 kWh/yr/households or 1,125 kWh/mth/household

1st 250 kWh @ 5.902¢/kWh =	$14.76
Balance 875 kWh @ 2.988¢/kWh =	26.15
Service Charge	9.44
TOTAL	$50.35/mon

Effective Residential Rate $50.35/1125 kWh = 4.5¢/kWh.

b) Commercial/Institutional:
If on the Manitoba Hydro grid, the average charge to commercial institutional users would approach 3.5¢/kWh

c) Hydroelectric charges for the same amount of electrical useage are included in O/M estimates. However, the total transmission line O/M and energy costs are similar to hydroelectric O/M charges including energy (See Financial Analysis of Energy Alternatives Section of this report). This implies that user fees for hdyroelectric could be similar to transmission line user fees.

Intermediate 100 amp. residential users would increase revenue to Manitoba Hydro from $40 k ($1983) per annum to $130 k (1983) per annum in 2008.

Transmission Line Rates - High Load

High load 100 amp service (electric heat) user fee estimates are calculated as follows:

High Load 100 amp:

a) Residential Rate:
27 500 kwh/year/household or 2292 kwh/month/household
(assumes 20% of heating requirements supplied by wood)

1st 250 kwh @ 5.902¢/kwh =	$14.76
Balance 2042 kwh @ 2.988¢/kwh =	61.01
Service Charge	9.44
Total	$85.21

Effective Residential Rate $85.21/2292 = 3.7¢/kwh

b) Commercial Institutional Rate:
Assuming Manitoba Hydro grid cost of 3.5¢/kwh

Revenue generated to Manitoba Hydro will increase from $40 k (1983 $) per annum to $441 k (1983 $) per annum for residential users by the year 2008. Commercial/institutional users will generate a revenue decrease from $265 k (1983 $) per annum to $193 k (1983) per annum in 2008.

Consumer Rates Summary

The accompanying Table 10-1 summarizes the above information. It is observable that intermediate 100 amp service (no electric heat) could cost consumers an additional $21.16 (1983 $) per month on average which should experience considerable acceptance at the community level given the associated benefits. Commercial and institutional users could experience dramatic reductions in user fees if intermediate 100 amp power were available at grid rates. These significant reductions may cause commercial/institutional users to contribute to the cost of enhanced power installation.

High load 100 amp service (electric heat) would cost the residential user approximately $56.02 (1983 $) more per month than is being paid now. This increased cost is similar to the average cost of wood procurement per household as identified elsewhere in this report. However, the forecast assumes 20% of heating requirements are still satisfied by wood so the total energy cost would probably approach $95 (1983 $) or $66/month more than is being paid now. This $66/month increment is still realistically close to the present average monthly expenditure on wood hauling $55 - $60 (1983 $) as discussed elsewhere in this report. Commercial/industrial users would again experience

significant savings in costs and could heat their premises electrically for less cost than presently incurred by diesel/wood/oil energy systems.

The local survey discussed earlier in this report identifies that in excess of 90% of study area residents would convert to electric heat if costs would be similar to the costs presently incurred in procuring wood resources. The above consumer rate discussion indicates that transmission line electric heat would not only be desireable but also economically acceptable to study area residents.

Summary
Electrical Energy Consumer Costs
(for Comparison Only)

MWH/$1,000's (1983) per annum

Table 10-1

	Residential	Commercial/ Institutional	Total
1983 Average Cost	575/$40 $29.19/home 7¢/kwh	581/$265 35¢-57¢/kwh	1156/$305
2008 Diesel Continued Average Cost	1850/$130 $29.19/home 7¢/kwh	1350/$572 35¢-57¢/kwh	3200/$702
Intermediate 100 amp Average Cost	5800/$263 $50.35/home 4.5¢/kwh	2000/$70 3.5¢/kwh	7800/$330
High Load 100 amp	1200/$441 $85.21/home 3.7¢/kwh	5500/$193 3.5¢/kwh	17,500/$634

10.2 Development Related Employment

The most immediate benefit of the proposed energy development alternatives would be the creation of construction employment opportunities for study area residents. The accompanying table 10-2 provides an estimate of the unskilled employment opportunities associated with proposed energy developments.

While the most economical of the new alternatives discussed, the transmission line from Lynn Lake to Lac Brochet would create the most unskilled employment opportunities at $1,080 k (1984) or 40 man years for study area residents. Transmission line construction would require two (2) years of effort with bush clearing being the prime unskilled activity of area residents. Clearing should be able to be undertaken for 10 months of the year allowing for thaw and freeze-up. The following number of unskilled positions and remuneration is associated with the transmission line alternatives:

Transmission Line Unskilled Labour:

	Year 1	Year 2	Total
Man Years Required	20	20	40
Man Months	240	240	480
10 Month Season/Job	24 jobs	24 jobs	48 jobs
Total Remuneration (1984 $)	$540,000	$540,000	$1,080,000
Average Remuneration/Job	$22,500	$22,500	

Transmission line construction could potentially create 24 unskilled jobs for two periods of 10 months duration over the 2 year construction period. The local study area could readily supply 12 or so individuals from each community to satisfy the job opportunities identified. Wage levels would approach $13.00 per hour including benefits.

Unskilled employment for a hydroelectric development would follow a three (3) year construction schedule with approximately 17% of total unskilled employment generated in Year 2 and the remainder, 83%, generated in Year 3. Approximately 80% of the work would be undertaken during the summer season. The following job creation and remuneration is associated with the intermediate load, Brochet and Lac Brochet development:

Hydroelectric Intermediate Load Brochet & Lac Brochet Unskilled Labour:

	Year 1	Year 2	Total
Man Years Required	3.9	19.1	23
Man Months	46.8	229.2	276
Summer man months (80%)	37.4	183.4	220.8
5 Month Season/Job	7.5 jobs	36.7 jobs	44.2 jobs
Winter man months (20%)	9.4	45.8	55.2
5 Month Season/Job	1.9 jobs	9.1 jobs	11 jobs
Average Remuneration/Job	$11,250	$11,250	

Intermediate hydroelectric development could create 55 unskilled jobs for a 5 month period per job during the three year construction period. A relative peak of 36.7 jobs would be reached in the summer of the third year. Again, the study area should be able to satisfy most of the 18 - 19 jobs per community created by this energy alternative. Remuneration will be similar to other potential developments at $13.00/hour including benefits.

Similar methodology can be applied to the hdyroelectric high load case with this alternative creating approximately 12 more 5 month jobs over the three year construction period.

By applying an employment "credit" against the present value costs generated earlier in this report, the net cost benefits when considering employment only tend to provide additional support for transmission line development as follows:

1984 dollars (000's)	Amortized P.V. Costs	Job Creation Credit	Net Cost Benefit
Alternative			
Diesel - B & LB	$21,078	-0-	$21,078
Hydroelectric - Inter. B & LB	27,776	634	27,142
Hydroelectric - High B & LB	27,511	810	26,701
Transmission Line - Inter B & LB	24,674	1,080	23,594
Transmission Line - High B & LB	17,193	1,080	16,113

On-going job creation for maintenance, operations, etc. will be minimal.

Unskilled Labour Requirements

Man Years 1984 dollars

Table 10-2

	Brochet & Lac Brochet	Brochet Only	Lac Brochet Only
Hydroelectric Development			
Intermediate Load 100 amp.	2-600 kw units 23 man years $620,000 1-600 kw units .5 man years $14,000	2-500 kw units 7.7 man years $208,000 1-500 kw units .5 man years $14,000	2-300 kw units 7.2 man years $200,000 1-300 kw units .3 man years $8,000
Full Load 100 amp.	2-1750 kw units 28 man years $760,000 1-1750 kw unit 2 man years $50,000		

Transmission Line:

Lynn Lake - Brochet	$700,000 26 man years	mostly brush clearing
Brochet-Lac Brochet	$380,000 14 man years	mostly brush clearing

10.3 Lifestyle and Area Developments

Major life style shifts will probably not be created by the introduction of intermediate load 100 amp. service to the study area. Almost all residences utilize 15 amp. service and have been doing so for the past while. The introduction of intermediate load 100 amp service will enhance the convenience of using electrical appliances and save some wood hauling time due to the probable increased use of electric stoves. Enhanced convenience and the minimal saving of some wood hauling time should have an insignificant (if any) effect upon study area lifestyle.

The introduction of 100 amp full load hydro, capable of providing electric heat, may have some effect upon study area lifestyle. Previous discussion has indicated that the marginal costs of electric heat as per grid pricing assumptions are almost equivalent to the costs presently incurred by the average household in the practise of obtaining fuel wood. Assuming a majority of households were to convert to electric heat, the average 132 man hours per household currently spent in obtaining wood for fuel would become "free time". Conservation of existing wood resources, along with available time to pursue/create job opportunities, are highly desired by area residents as per the local survey. At present, neither community contains sufficient employment opportunities, upgrading/training programs, recreational amenities, etc. to enable residents to make effective use of this time. Albeit, the term "effective" in this regard is relative and resultant life style effects indeterminate.

The local survey indicated that most residents wanted local administrations to pursue economic development and job creation opportunities. This potential "free time" will enable residents

to undergo upgrading training in order to implement local developments which are presently not possible due to high electrical energy costs.

The introduction of enhanced electrical service will benefit existing institutional/commercial users in terms of greatly reduced electrical energy costs. Institutional users will realize direct monetary savings in operating their respective service outlets. Commercial ventures will experience a reduction in operations and/or production costs and will either pass these savings on to final consumers or realize increased profits.

Earlier sections of this report discuss potential economic developments which are presently not justifiable from an economic viewpoint due to the high cost of energy infrastructure. This is not to imply that the provision of adequate electrical energy at reasonable cost will create development. Viable economic development, and especially when considering remote locations, can only be successfully introduced if market conditions support such development. While energy costs or other factors may inhibit economic development, the removal of such barriers does not necessarily lead to economic development if market conditions are not supportive. In this regard, the aforementioned economic growth potential focuses on those developments which attempt to satisfy the needs of the Brochet - Lac Brochet target market only. Barring unforeseen major development impetus such as mineral discovery, for example, the study area can only hope to take advantage of its own growth and available resources.

Economic developments with future potential as based upon projected growth and reasonably priced energy infrastructure could include:

- retail store/shopping expansion at both Brochet and Lac Brochet
- bakery to service both communities
- housing repair/renovation in each community
- electrical installation/repair in each community
- laundromat in each community
- central tourism facility

Social support developments will be required and/or introduced as the study area experiences natural growth. Adequate electrical energy infrastructure is not a necessary pre-requisite for social development but would probably serve to decrease the energy capital costs and related operating costs of such developments.

11.

OBSERVATIONS AND CONCLUSIONS

11. OBSERVATIONS AND CONCLUSIONS

1. This energy demonstration study was initiated by the communities of Brochet and Lac Brochet out of concern for finite wood fuel resources and the ever increasing cost of fuel oil, gasoline and other fossil fuels. Diesel generators provide limited 15 amp. service to residential customers. The communities rely upon wood for residential heat and cooking. Diesel fuel, fuel oil and gasoline are transported to the communities via air transport or winter road.

2. The study area presently contains 972 individuals including Treaty Indian and Metis. These community members reside in 136 homes with an average occupancy of 5.8 - 6.0 per household. Non-Natives reside in the area as a result of professional employment opportunities. Study area economies are generally depressed with few employment opportunities available. Present economics are predominantly traditional including hunting, fishing, trapping and firewood gathering.

3. As per past growth trends, the study area population will almost triple to 2,590 individuals over the next 25 years. Housing stock will increase to 416 units as per current housing allocations. This increased population will require enhanced social support, community and economic development.

4. Present energy costs experienced in the study area are estimated as follows:

TOTAL ENERGY COSTS (1982/83) BOTH COMMUNITIES

	Electricity 82/83 ($)	Gasoline/ Wood 82/83 ($)	Oil 82/83 ($)	Propane 82/83 ($)	Total Estimated Cost ($)
Brochet					
Treaty	$ 28,800	$ 61,950	$ 2,378	$-0-	$ 93,128
Metis	13,100	25,800	-0-	-0-	38,900
Non-Native	147,140	-0-	135,646	$2,434	285,220
Lac Brochet					
Treaty	11,180	89,100	32,500	3,900	136,680
Non-Native	143,655	-0-	19,468	3,546	166,669
TOTALS	$343,875	$176,850	$189,992	$9,880	$720,597

Average cost per KWh for each source in 82/83 was:

Electricity 25.7¢/kWh (B) 57¢/kWh (LB) Full Cost Diesel

Firewood 3.5¢/kWh ($115/cord @ 65% efficiency)

Oil 7.2¢/kWh (42.3¢/L - 83¢/L @ 60% efficiency)

5. Significant energy conservation potential exists in the study area. Field investigation has yielded the following cost saving estimates:

SUMMARY OF ENERGY CONSERVATION POTENTIAL

	Projected Savings ($/yr)	Estimated Cost ($)	Simple Payback (yrs)
Air Leakage Reduction	$79,600	$125,000	1.6
Insulation	3,500	9,000	2.6
Lighting Conversion	7,000	6,000	.85
Temperature Setback	6,000	1,000	.17
Oil Furnace Efficiency	20,000	12,000	.6
TOTAL	$98,100	$153,000	

6. Three electrical load alternatives were considered in this analysis;

   Low Load - existing diesel, 15 amp. residential service

   Intermediate Load - 100 amp. residential service, no electric heat

   High Load - 100 amp residential service, electric heat

   Total community energy requirements incorporating the three (3) electrical load alternatives were estimated as per Table 11-1.

7. Trees in the study area are predominantly Black Spruce which is being utilized for residential heating and cooking. Due to unfavourable growing conditions, trees are usually smaller and require 200 years rotation age (maturity). Fires have burned roughly half of the land area. The annual rate of burn over the past 33 years has averaged 1.5%, amounting to 46 km^2 (18 s.m.) or roughly half a township per year.

Wood consumption per home is difficult to estimate and a range of 11 - 18 cords per annum has been discussed in this report. At 18 cords per annum, approximately 100,500 cords of fuel wood will be harvested over the next 25 years. Present fuel wood reserves have been estimated at 859,300 cords.

There appears to be no imminent threat of wood resource depletion. However, access distance will increase over the planning period while additional fires may severely reduce available resources.

8. Preliminary investigation has determined that at least two (2) possible sites on the Cochrane River are capable of accommodating hydroelectric development requirements. Capital costs for potential hydroelectric development have been estimated as follows:

Hydroelectric Development
Capital Cost Estimates $1984 - 000's

	Single Site Brochet & Lac Brochet	Brochet Alone	Lac Brochet Alone
Low Load	$13,500	$7,900	$8,800
Intermediate Load	18,200	11,500	10,400
High Load	27,800	n/a	n/a

Transmission line tie-in with the Manitoba Hydro grid system at Lynn Lake is a plausible alternative. Capital costs for transmission line tie-in have been estimated as follows:

Transmission Tie-in
Capital Cost Estimates - $ 1984 - 000's

Lynn Lake-Brochet - $7,680 Brochet-Lac Brochet - $5,460

TOTAL Lynn Lake-Lac Brochet - $13,140

Operation and maintenance costs for hydroelectric alternatives are estimated at 1.7% of capital cost and include the cost of energy. Operation and maintenance costs for transmission tie-in have been estimated at 1.2% of capital cost. The additional cost of energy provided by the grid connection at Lynn Lake has been identified as a separate item and included in this analysis.

9. Environment impacts of either intermediate load hydroelectric or transmission line connection would not be too significant. Concern would rest with a slight elevation in river level, minimal flooding, aesthetics of road/transmission access and possible effects upon caribou migration.

10. The various energy alternatives were analyzed by examining the total energy requirements of the two communities including electricity, oil, wood/gasoline and propane. All capital, O/M and energy costs were projected forward on the basis of determined load projections assuming a rate of inflation of 8%. The capital cost of the various alternatives was amortized over the useful econmic life of the various developments. These flows were discounted at 12% thereby resulting in an effective discount factor of 4%.

The present value analysis applied to the various alternatives is presented in Table 11-2.

Of all the alternatives considered, transmission line tie-in under high load energy assumptions is the most economical alternative to the communities. Continued 15 amp diesel generation along with required oil, wood/gasoline and propane, will cost the communities approximately $3.9 million or $155,000 (1984 $) per annum more for energy requirements over the next 25 years as compared to high load transmission line tie-in.

All other variations concerning separate developments or tie-ins are more costly than the transmission tie-in for Brochet/Lac Brochet discussed above.

Projected Energy Requirements
Brochet & Lac Brochet

Table 11-1

	Present 1982/83	1988	1993	1998	2003	2008
Low Load						
Brochet:						
Diesel (kw/mWh)	210/886	246/1040	271/1159	406/1716	446/1899	496/2125
Oil (l)	303,464	303,464	303,464	436,800	436,800	436,800
Wood (Cords)	1,001	1,386	1,661	1,991	2,431	2,970
Gasoline (l)	65,156	90,216	108,116	129,596	158,236	193,320
Propane (kg)	2,190	2,190	2,190	4,630	4,630	4,630
Lac Brochet:						
Diesel (kw/mWh)	66/270	129/512	149/599	196/803	221/931	248/1059
Oil (l)	76,910	122,120	124,120	190,000	192,000	194,000
Wood (Cords)	495	770	990	1,210	1,485	1,760
Gasoline (l)	43,245	67,270	86,490	105,710	129,735	153,760
Intermediate Load						
Brochet (kw/mWh)	210/886	585/2143	816/2721	1097/3757	1265/4307	1475/5000
Oil/Wood/Gasoline same as Low Load - Propane not required						
Lac Brochet (kw/mWh)	66/270	302/985	447/1559	612/2016	747/2946	852/2793
Oil/Wood/Gasoline same as Low Load - Propane not required						
High Load						
Brochet (kw/mWh)	210/886	1421/4815	1765/5759	2554/8566	2901/9436	3337/11172
Wood (cords 20% Low Load)	200	277	332	398	486	594
Gas (L - 20% Low Load)	13,030	18,045	21,623	25,920	31,467	38,664
Oil/Propane not required						
Lac Brochet (kw/mWh)	66/270	766/2471	1144/3651	1451/3651	1768/5631	1991/6368
Wood (cords 20% Low Load)	99	154	198	242	297	352
Gas (L - 20% Low Load)	8,649	13,454	17,298	21,142	25,947	30,752
Oil/Propane not required						

Present Value Comparisons
Energy Alternatives
Brochet & Lac Brochet

Table 11-2

(000's)	Amortized Capital Cost	Operations/ Maintenance	Energy Cost	Total Cost
Continued Diesel - Low Load incl. Wood/Gas, Oil, Propane	$1,170	$10,003	$9,905	$21,078
Hydroelectric - Intermediate Load incl. Wood/Gas, Oil	14,610	3,463	9,703	27,776
Hydroelectric - High Load incl. 20% Wood/Gas	23,144	3,414	953	27,511
Transmission Line - Intermediate Load incl. Wood/Gas, Oil	11,839	1,918	10,917	24,674
Transmission Line - High Load incl. 20% Wood/Gas	11,839	1,918	3,436	17,193

APPENDIX A - BROCHET PRESENT ENERGY USE

Notes to Table 5-1

Brochet Treaty

1. Housing:

The total number of liveable Treaty houses is estimated at 50. Most houses are detached bungalows with frame construction over a crawlspace and an insulated main floor. Forty-four 44% of the houses are about 900 sq.ft. while the remainder are less than 800 sq.ft. According to the survey results, 64% of the respondent's homes contain R12 and 28% contain R20 insulation throughout.

None of the houses inspected had weatherstripping on doors or attic hatches and the slider windows were draughty.

As electricity to the houses is provided by diesel generation, they are subject to a service capacity limitation. Each house has either a 100 amp or a 125 amp electrical distribution panel, but only a dual 15 amp main breaker is used in order to obtain a residential rate.

Inspection of two electrical panels revealed that a single phase 240 V supply with a neutral is used, yielding two 120 V circuits. Although the 240 V supply is limited to 15 amps, the homes actually have 30 amps available at 120 V.

Due to time restraints, it was not determined which receptacles are wired to which of the two 15 amp circuits. To reduce the problem of frequent breaker tripping, and to render the existing wiring more useable, it is recommended that each receptacle, lighting and other outlets be labelled circuit A or circuit B. In this manner the resident will know the limitations of each receptacle.

In view of present service capacity limitations, the contribution to the electrical consumption is 4,327 kwh. Therefore, the 50 treaty houses, the total estimated electrical requirements are 50 kw (peak demand) and 216 350 kwh/a (annual consumption).

According to the housing survey, 9 boat loads and 36 "skidoo" loads of cord wood are used by each household each heating season. From conversations with local residents it was roughly estimated that it takes 4 boat loads to total a cord and 8 skidoo loads to total a cord. This yields a total wood consumptioon per household of 6 3/4 cords.

Since the report "Energy Profiles for Manitoba Remote Communities" assumed 16.7 cords per residence and the housing survey data yields 6 3/4 cords, we performed a detailed heat loss calculation of an 800 sq.ft. house with R12 insulation throughout to find the correct number of cords used. The peak heating requirement was calculated to be 12 kw. This calculation used a 40 year term Brochet meteorological data of 8,452 degree day celcius (DD) below 18°C and a design winter temperature difference of 63°C.

Manitoba Hydro estimates the annual heating energy requirement of a fully serviced house as:

$$Q_{annual} = (\text{Peak kw heating requirement}) \frac{(DD)\ 14}{\dfrac{(\text{at Design Winter Temperature})}{\text{Maximum Indoor to Outdoor Temperature Difference}}}$$

The number 14 is the normal factor that assumes heating is required for only 14 hours out fo 24 hours because of internal energy gains from lights, appliances, people, hot water heater, TV, etc. and solar gains. As study area houses have limited service capacities (very few appliances), with absolutely no internal or solar gains. Therefore, the annual energy consumption of the average study house would be:

$$Qa = \frac{(12\ kw)\ (8{,}462\ DD^{o}C)\ (19\ hrs)}{63^{o}C} = 30{,}600\ kwh$$

From the Bio Mass Institute, a cord of dry Lodge Pole pine, which is similar to the standing burnt Jack pine that is the predominant wood burned in the area, contains about 5,000 kwh of energy. Using an average wood stove efficiency of 65%, the number of cords consumed per household is 9.4 cords.

Heat loss calculations assumed on a house air change rate (ACR) of 1.0 per hour, which is characteristic of 15 to 30 year old houses. Since area houses do not have weatherstripping and have draughty windows, a higher ACR will probably occur. Therefore, an average of 11 cords per household or 550 cords for Brochet Treaty houseing was assumed.

A possible explanation for the discrepancy between the housing survey estimate of 6 3/4 cords and the calculated value of 11 cords may be due to the high solid wood content of bare small diameter Jack pine stacked in a 4' x 4' x 8' cord.

Wood of larger diameter and with branch stubs and bark will stack with more air space and less solid wood content than the bare Jack pine. A normal piled cord of wood would have a solid wood content of only 80 cu. ft. whereas the tightly packed Jack pine could be in excess of 100 cu. ft.

Both the housing survey and site investigation discovered poor distribution of wood stove heat. This is due to interior wall partitions that block the natural heat flow. The wood stove, which sometimes doubles as a cook stove, is usually located in the common area between the kitchen, living room and front entrance. If electric heating is not going to be used in the future, perhaps a sheet metal canopy and small fan located over top of the wood stove could distribute heat through ductwork to the bedrooms.

2. Other Buildings(Band office/pool hall/community hall/post office)

The only building which the study team could gain access to was the Band Office. The office is a 40' x 25' bunglow over a crawl-space with a floor, insulated to R12. The walls also contain R12 insulation. The windows are found to be draughty and the doors and attic hatch in need of weatherstripping.

From conversations with band members, the other buildings in this group are used only occasionally and are heated by wood. The DIAND building is vacant and is planned to be used as a motel in the future.

The DIAND building is heated with a forced air oil furnace rated at 140,000 BTU/h which, according to office staff, consumes 20 barrels of oil per year. At 205 L per barrel, this amounts to 4,100 l per year. Also according to the staff, they pay $90 per barrel for the fuel and a $30 per barrel shipping fee. This amounts to a total annual fuel cost of $2,400.

All of these buildings have a service capacity limitation of dual 15 amp, and together consume about 10,000 kwh/a and contribute about 2 kw to peak electrical demand.

3. Other Facilities:

Pump House: The pump house contains the following energy consuming equipment: two 7 1/2 hp vertical turbine pumps rated at 75 gpm each (only one runs at a time, the other is a backup), one 93,000 BTU/hr forced air oil furance, one 5 kw electric unit heater, a 7 1/2 hp backwash pump motor, and 228 ft. of heat tracing on the 6 in. diamater line that runs to the lake.
Assuming that the 7 1/2 hp vertical turbine pump operates 80% of the time, the furnace motor consumes 2,260 kwh/a, the 5 kw electric unit heater does not come on, the backwash pump is rarely

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used, and since heat tracing uses 6.3 watts per metre, the total estimated consumption and peak kw for the pumphouse is 40,000 kwh/a and 8 kw respectively.

Water Distribution System: According to original drawings of the water supply and distribution system, the water outlets terminate at 5 watering points and three buildings (nursing station and DIAND buildings). The 5 watering points are about 30 ft. from the main 6 in. diameter line and are heat traced. Some of the watering point sheds contain propane heaters. The 3 buildings served directly are a total of 200 ft. from the main line. Assuming heat tracing for these 8 3/4 in. lines is operable, the total electrical consumption and peak kw for the water distribution is estimated at 7,600 kwh/a and 1 kw respectively.

4. Metis Housing:

The total number of liveable Metis houses is estimated at 41.

While Metis houses are of the same construction as Treaty houses, Metis houses have less insulation - 83% of the houses contain R12 while 17% contain R20 throughout. Thirty-nine percent (39%) of the houses average about 960 sq.ft. in size while 51% are less than 860 sq.ft. None of the houses inspected had weatherstripping on door or attic hatches and the slider windows were draughty.

Each house is subject to the service capacity limitations of a dual 15 amp main breaker. The comments on Treaty housing electrical systems also apply to the Metis housing with the exception that average electrical Metis consumption is slightly less at 4,249 kwh/a at an average cost of 7.5¢/kwh. Due to present service capacity limitation, about 1 kw per house is the estimated contribution to the electrical peak demand.

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The total electrical consumption and peak kw for the 41 Metis houses is estimated at 174,209 kwh and 41 kw respectively.

According to the housing survey, Metis houses require about the same number of boat and "skidoo" loads of cord wood for as heating as Treaty houses. The comments on cord wood for Treaty houses also apply to the Metis houses except that the total wood used for these 41 houses is estimated at 451 cords.

5. Non-Native:

Fathers and Sisters House:
Fathers House was constructed in 1952, is a 2,000 sq.ft. storey and half house of a wood frame construction on a concrete foundation with basement. The attic contains about 8 in. of sawdust, walls do not have any insulation. The old wood slider windows and the lack of weatherstripping indicate a high rate of air leakage for this house.
Sisters House was locked and could not be inspected. However, this structure is a newer bi-level house comprising 1,440 sq.ft. of wood frame construction and uses oil for space heating and propane for water heating. The Father told us that both houses are on the same electrical service capacity limiation as the rest of the community.
The Fathers house is heated with a 97,000 BTU forced air oil furance. According to the Father, both houses use a total of 1,500 gallons (6,800 l) of oil and 90 kg of propane annually.

Church:
The Church, constructed in 1948, is a 2,300 sq.ft. single storey building of a wood frame construction on a stone foundation with basement. The insulation levels are similar to the Fathers House and also contain no insulation on the basement walls. The

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windows are mainly single pane and the building is judged to have a high degree of air leakage.
According to the Father, about 8 cords of wood is used annually to heat the Church through a basement wood stove. Six (6) 100 watt incandescent light bulbs are the only electrical consuming items in the Church. Assuming lights are used 90 hours per month, they will consume 648 kwh/a.

School and Teacherage:
The school is 25,000 sq.ft. and is of a wood frame construction on a concrete foundation with insulated crawlspace walls. In general, the walls of the newer sections of the school are insulated with R12.
The wall vents in the heated crawlspace of the new section of the school were found to be open to outdoors. This was mentioned to maintenance staff and it was recommended that these be closed tight for the winter months.
The weatherstripping on all doors was badly torn. Since the doors are only single sets, it is recommended that vestibules with a second set of doors be added to all doors with high pedestrian traffic.
There are a total of 13 forced air oil furnaces rated at 140,000 BTU/h in the school. Each furnace, which may serve one or more zones, is controlled by one thermostat. Each furnace has a manual day/night switch to place the furnace fan on continuously during the day and at night, only when the furnace burner fires. There is no temperature setback in the school
The furnace is equipped with fresh and return air dampers, ie: outside and inside air can be mixed before it passes through the furnace. For the 6 furnaces in the old school section, the temperature sensor that controls the dampers is located on the furnace supply duct. They were found to be set between 55°F and 70°F. When any of the 13 furnace fans is on but the burner is not firing, the furnace will bring in some cold air, as determined by the

5. con't

temperature sensor. (The amount of cold air that would enter as a result of leakage through the damper even if the damper was closed is about 10 to 15% of rated volume.) However, for the old section, when the burner fires, the control system will try to bring in enough fresh air to keep the supply air temperature at the set-point. The result is that the fresh air damper is usually wide open when the burner is firing. This heating of unnecessary outside air is very energy wasteful.

To reduce most of the waste on the 6 furnaces, the temperature sensors should be relocated in the mixed air plenum, and they should be set as high as is acceptable to maintain a proper air quality in the school. Fresh air dampers should not be allowed to open when the school is unoccupied. In view of the high rate of air leakage in the school and the relatively few hours per day that the building is used, consideration should be given to replacing the existing fresh air dampers with a low-leakage type. Given the relatively low hours of school building useage, 15°F optimized temperature setback for 128 hours per week could save about 15% of the annual oil consumption. Another method of reducing energy waste is to improve the efficiency of the furnaces, including ensuring that the fan thermostat settings are in the order of 100°F on and 80°F off off, using recently developed flame retention high efficiency burners.

According to maintenance staff, washroom exhaust fans are manually turned off in evenings and during weekends. If automatic control is desired to guarantee that these fans are off, time clocks should be installed.

Most of the school lighting is provided by standard (cool white) fluorescents. These should be replaced immediately with low-wattage lamps. Consideration should be given to replacing the fluorescent lamp ballasts with the Philips Mark III high efficiency ballast, or equivalent, not only for the energy savings, but also for the 5 year warranty and a rated life that is 2 to 3 times longer than conventional ballasts.

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All incandescent lamps should be replaced. However, the choice of alternate lighting source, such as for the gymnasium's 300 watt incandescent lamsp, must also take into account the voltage fluctuation to which the community is prone. High intensity discharge lamps such as metal halide or high pressure sodium can go out under these circumstances, and they require a 10 to 20 minute period for re-starting.

The teacherages (total area 8,950 sq.ft.) consist of trailers, a fourplex and detached bungalows of various ages. Most of them are wood frame construction on a concrete foundation with a crawlspace.

The unit inspected, trailer #2, consisted of two 20'x40' Atco trailers with a forced air oil furnace and a 40 amp main breaker. The trailer contained a propane stove and domestic water heater.

The energy use for the school, teacherage and the sewage lift station (2 - 1 1/2 hp sewage pumps) is as follows:

kwh/a	232,235
kw (est)	72
oil (l)	215,180
propane (kg)	2,070

Nursing Station (New and Old) and Garage:

The new nursing station, constructed in 1979, is a one story metal clad building with a concrete basement. The thermal resistance of the walls and ceiling are unknown. The basement walls are insulated, the windows are triple pane, and the building appears to be fairly air tight.

Two 140,000 BTU/h forced air oil furnaces each with a mixed air system serves to heat and ventilate the building. An oil-fired 70 USG hot water tank and a standby generator are also located in the same basement mechanical room as the furnaces.

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The old nursing station consists of two large trailers and a house addition and is presently used only for accommodating visitors. The old station is seldom used and its five 90,000 BTU/hr forced air oil furnaces are operated only to maintain a minimum temperature in the station.
The maintenance garage is about a 500 sq.ft. insulated building that is used only occasionally. The garage contains an oil furnace and a portable electric heater.
The total energy requirements for all three buildings is estimated as follows:

kwh/a	79,970
kw (est)	10
oil (l)	34,777

Hudson Bay Store and Houses:
The Hudson Bay Store, constructed of wood frame sheet metal walls, is about 4,700 sq.ft. on the main floor with a loft for storage and a partial concrete wall basement. The basement walls and crawlspace walls are insulated and the structure has a high degree of air leakage, particularly in the older building sections. There is a few inches of wood shavings in the attic of the 1 1/2 storey section and R10 insulation over the newer section ceiling. The store has a large number of electrical appliances such as coolers, freezers, etc., and its own heat traced pumped water system. As well, the 40 gallon hot water tank is heated with 4,500 watts of electric elements.
There are approximately 6 kw of fluorescent lamps and 5 kw of freezers and furnace and exhaust fans.
The residences consist of one modern bungalow of about 1,200 sq. ft. and an older 900 sq.ft. storey and a half house. Both are heated with oil.

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The total energy costs for all three buildings is listed as follows:

kwh/a	83,500
kw (est)	14
Oil (1)	21,302

RCMP Trailer and Cell Trailer:
The manned RCMP trailer is a 1,200 sq.ft. Coleman mobile home with R12 ceiling and walls, R20 floor, double pane windows and a front entrance vestibule.
The trailer has the same dual 15 amp service capacity limitation as the other houses. However, it is wired for a future dryer, washer, hot water tank and range.
An 84,000 BTU/h forced air oil furance serves as the space heater. The trailer also contains a propane stove and hot water tank. The Cell trailer is seldom used. It is a 300 sq.ft. ATCO trailer with a 105,000 BTU/h forced air oil furnace.
The total energy requirement for both trailers was obtained verbally from the Winnipeg RCMP Detachment as follows:

kwh/a	6,654
kw (est)	1
Oil (1)	9,305
Propane (est)	30 kg

MTS Building:
This building consists of a small trailer of about 150 sq.ft. and contains electrical communication equipment. The total energy requirement was obtained verbally from the Winnipeg Head Office as follows:

kwh/a	7,765
kw (est)	4

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Airport Terminal and Garage:

The terminal is about a 1,300 sq.ft. building of frame construction insulated with R12 in the walls and attic. The terminal has single pane slider windows that are covered with plastic in winter and the building is judged to be very leaky.

The electrical distribution panel is limited to 100 A. The study team was advised that some type of load shedding system is in effect as the runway lights were turned off in the midst of our plane landing.

The terminal is heated by a 115,000 BTU/h oil furance. Two other buildings, 1,200 sq.ft. and 800 sq.ft. have similar sized furnaces.The larger building has R20 walls while the smaller building has R12 walls.

The 2,000 sq.ft. garage has a concrete slab on one side and a sand floor on the other. Roof and wall insulation values are unknown. Two 112,000 BTU/h forced air oil furnaces supply the heating requirements for this garage.

The total energy requirements as well as some of the construction details were obtained verbally from the Department of Highway and Transportation (Airport Division) as follows:

kwh/a	13,714
kw (est)	4
Oil (l)	8,000

Diesel Generator Plant:

The diesel generator plant consists of the following generators:

- 2 @ 210 kva, 175 kw, 1,800 rpm 347/600 v installed June of 1973 and 1974
- 1 @ 375 kva, 300 kw, 1,200 rpm 347/600 V installed June 1976

Total 650 kw

According to Manitoba Hydro, there are about 3 more years of life left in the 175 kw machines and 6 years for the 300 kw machine. Each machine goes through a regular quarterly maintenance program.

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During investigation on October 12, 1983 (noon) only one of the 175 kw generators was operating and the registered peak was only 126 kw in the 1981/82 season. The diesels alternate for even operation and reject their heat to the outdoors.
The machines generate at 600 V. This level is stepped up to 8 kv for transmission and reduced on pole mounted transformer to a 120/240 volt 1 phase supply that is provided to most buildings.
According to Hydro, the drop lines to each of the houses, #2 ASCR cable, has a 140 amp capacity.
The diesel fuel consumption of 430,000 l for the 1981/82 period was the only available consumption from Hydro.
Based on total consumption for 1981/82 of 921,156 kwh and for 1982/83 of 834,412 kwh, the 1982/83 diesel fuel consumption on a proportional basis was calculated at 390,000 l.

OPERATING EXPENSE AND REVENUE

Capital for: Department of Indian Affairs
Manitoba Hydro

BROCHET

Operating Costs:	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
General Maintenance Labour & Expense	$ 2 771	$ 5 186	$ 7 877	$ 5 180	$ 22 886	$ 19 514	$ 16 399	$ 26 570	
Parts	6 450	3 958	9 000	4 203	11 594	12 078	20 274	11 895	
Travelling Expense	2 969	3 362	3 940	3 448	-	6 754	6 331	5 767	
Contract Labour	2 734	2 996	3 784	4 181	4 922	5 638	6 350	6 463	
Fuel and Lube Oil	84 308	75 647	95 999	92 524	92 242	81 163	123 168	107 919	
Fuel Haulage Administration	23 619	1 686	385	35	342	516	-	1 565	
Administration	1 785	982	1 644	740	2 054	467	1 533	537	
Sub-Total	$ 124 636	$ 93 817	$ 122 629	$ 110 311	$ 134 040	$ 126 130	174 055	160 716	
Overhead	18 696	14 073	18 394	16 547	9 614	2 252	2 152	3 069	
Depreciation	5 969	14 677	21 451	23 190	23 350	20 899	20 749	22 660	
Interest	5 734	18 601	19 457	18 027	22 444	24 266	25 346	28 078	
Total Operating Costs	$ 155 035	$ 141 168	$ 181 931	$ 168 075	$ 189 448	$ 173 547	222 302	214 523	
Total Revenue	77 547	98 338	115 036	139 492	125 078	113 393	145 538	175 921	
Profit or (Loss)	($ 77 488)	($ 42 830)	($ 66 895)	($ 28 583)	($ 64 370)	($ 60 154)	(76 764)	(38 602)	
kWh Consumption	818 540	811 828	875 389	1 004 474	963 065	825 449	921 156	834 412	
Cost Per kWh ¢	18.9	17.4	20.8	16.7	19.7	21.0	24.1	25.7	
Return Per kWh ¢	9.5	12.1	13.1	13.9	13.0	13.7	15.8	21.1	23.7

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Notes to Table 5-2

Lac Brochet Treaty

1. Housing:

The total number of liveable Treaty houses is estimated at 45. The houses are detached bungalows, about 25% of which are log houses and are rapidly being replaced with new houses. The remaining houses are of frame construction over a crawlspace with an insulated floor. According to the survey results, 46% of the respondents homes contain R12 and 54% contain R20 insulation throughout. Also, 60% of the houses are about 650 sq.ft. while the remainder are less than 500 sq.ft.

None of the houses inspected had weatherstripping on doors or attic hatches and the slider windows were draughty.

Houses are subject to a service capacity limitation. Each house had either a 100 or 125 amp electricical distribution panel, however, only a dual 15 amp main breaker is used in order to obtain a residential rate.
Although called a 15 A service, because the current is supplied at 240 V, the homes actually have 30 amps available at 120 V as stated in the previous section (Brochet - Treaty). To reduce frequent breaker tripping and render existing wiring more usable, it is recommended that each receptacle, lighting and other outlets be labelled circuit A or circuit B. In this way, the resident will know the limitations of each receptacle.
Due to the higher electrical costs than Brochet, and the resulting lower usage, it is recommended that the contribution to the electrical peak demand is about 0.7 kw per house. As the survey did not have a response for average electrical consumption, about 70% of the consumption found in the housing survey for Brochet - Treaty, or 3,000 kwh will be utilized. For the 45 Treaty houses,

the total estimated electrical requirements are 30 kw (peak demand) and 130,000 kwh/a (annual consumption). According to the Brochet housing survey, the average cost for this electrical consumption is 7.8¢/kwh.

There was no response in the housing survey as to how many boat or skidoo loads of cord wood are used by each household. This study will assume similar use as for Brochet (Treaty), or 550 cords for 50 houses. Since Lac Brochet houses are smaller but the area is slightly colder, the same 11 cords/household (to yield a total of 45 x 11 = 495 cords) will be assumed. Both the housing survey and subsequent investigations found poor distribution of the wood stove heat. This is due to interior wall partitions that block the natural heat flow. The wood stove, which sometimes doubles as a cook stove, is usually located in the common area between the kitche, living room and front entrance. If electric heating is not going to be used in the future, perhaps a sheet metal canopy and small fan located over top of the wood stove could distribute heat through ductwork to the bedrooms.

2. Other Buildings (Band Office, Pool Hall, Community Hall)

The band office is a 40' x 25' bungalow over a crawlspace with an insulated floor. The walls contain R12 and ceiling R20 insulation. As in the Treaty houses, the windows were found to be draughty and the doors and attic hatch in need of weatherstripping.

The office, as well as other buildings, has a service capacity limitation of 15 amps at 240 V, and it is estimated that other buildings will consume about 10,000 kwh/a and contribute about 2 kw to peak electrical demand.

Fathers House and Church:

The Father's house is used occasionally by the Priest from Brochet. This is a 360 sq.ft. single storey house of a wood frame construction. The attic contains about 8 in. of sawdust, walls about 4 in. of insulation, and floor about 8 in. of insulation. The house is on the same service capacity limitation as the rest of the community.

The house is heated with a wood stove and we estimate that it uses only 2 cords per year.

The Church is used daily and is a 1,360 sq.ft. single storey building of log construction with wood panelling inside. There is R12 in the ceiling and floor, and 2 in. of insulation between the log wall and wood panelling. The windows are single pane glass and plexiglass, and the building is judged to have a high degree of air leakage.

It is estimated that 10 cords of wood are used annually to heat the Church via two wood heaters. Thirteen 100 watt incandescent light bulbs are the only electrical consuming items in the Church, and assuming they are used 90 hours per month, will consume 1,400 kwh/a.

School and Teacherages:

There are 4 double and one single classroom buildings each of a wood frame construction on a wood or concrete foundation with a crawlspace. In general, there is R20 in the attic, walls and floor of all classrooms except the single classroom building and one half of one of the double classroom buildings.

There is a 115,000 BTU/h forced air oil furnace for each classroom (total of 9).

A 15°F temperature setback in each classroom for 128 hours per week could save about 15% of the annual oil consumption.

The school lighting consists of cool white fluorescent lamps. These should be replaced immediately with low-wattage type lamps.

The double classroom buildings each have two 125 amp electrical panels with 50 or 100 amp breakers and are not subject to any service capacity limitation. The single classroom building, however, has a dual 15 A breaker and is limited in capacity.

The teacherages consist of three buildings, a 2 unit building and two detached bungalows. They are wood frame construction on a concrete foundation with a crawlspace.

The 2 unit building is insulated with R20 throughout and has two 100,000 BTU/h forced air oil furnaces and two dual 60 amp main breakers. It contains a washer, dryer and oil space heater for emergencies. One of the single units has a dual amp breaker, propane dryer and stove, and, a 100,000 BTU/h forced air oil furnace.

Associated energy requirements were obtained from a DIAND fuel delivery sheet as follows;

kwh/a	40,000
kw	14
Oil (L)	50,790
Propane (kg)	1,769

Since the Lac Brochet education facility is about one quarter the floor area of the Brochet school and teacherages, it will be assumed that the electrical consumption and demand is proportional.

3. Non-Native:

Nursing Station and Workshop:

The new nursing station was built in 1980, is a one storey wood siding building with a wood frame crawlspace. The thermal resistance of the walls, ceiling and insulated crawlspace walls are estimated at R20 throughout. The building appears to be fairly air tight except for the crawlspace where the vapour barrier was missing on the crawlspace walls. Two 90,000 BTU/h forced air oil furnaces serve to heat the building. Three oil space heaters serve as backup heating. Propane is used for water, dryer and stove heating. The nursing station has a 125 amp electrical box and a 100 amp double breaker.

The workshop is a 500 sq.ft. garage that is also used for storage. It has R12 in the walls, R24 in the attic and R40 in the floor. It is heated by a 48,000 BTU/h space oil heater and has a dual 60 amp main breaker.

The total energy requirements for the two buildings is listed as follows:

kwh/a	34,351
kw (est)	4
Oil (l)	13,548
Propane (kg)	1,575

General Store and Residence:

The store was constructed in 1981 and is 2,048 sq.ft. It has R20 in the ceiling and walls and R40 insulation in the floor and the building is fairly air tight.

A 112,000 BTU/h combination wood/oil furnace serves as the only source of heating and the owner has been burning more wood than oil since the store opened for business.

The store has a 125 amp electrical panel and a double 100 amp breaker. The owner indicates that present hdyro bills approach $1,500 per month.

The store owner's residence next door is a small bungalow, probably about 600 sq.ft and appears to be on a limited service capacity of dual 15 amp breakers.

Since this store and residence is about 1/3 the size of the Brochet - Hudson Bay Store and has less electrical appliances, it is estimated that it uses about one-quarter the energy of the Brochet store. The breakdown is as follows:

kwh/a	20,000
kw	7
Cords	20

RCMP Trailer:

The unmanned RCMP Trailer is a 360 sq.ft. Coleman mobile and although it was not inspected, it was assumed that it has an R12 ceiling and walls, R20 floor, double pane windows and a front entrance vestibule.

The trailer probably has the same dual 15 amp service capacity limitation as the other houses.

An oil furnace serves as the space heater and there is probably a propane stove.

The total energy requirement for the trailer was obtained verbally from the Winnipeg RCMP Detachment as follows:

kwh/a	3,609
Oil (l)	2,000
Propane	30

MTS Building:
The building consists of a small trailer about 81 sq.ft. and contains electrical communication equipment. The total energy requirements were obtained verbally from the Winnipeg Head Office as follows:

kwh/a	14,118
kw (est)	4

Airport Terminal and Garages:
The terminal is a 300 sq.ft. building of frame construction insulated with R20 throughout. The terminal has two single pane skylights and an insulated steel door.

The electrical panel has a dual 30 A breaker and there is a 45,000 BTU Coleman space oil heater.

Two other buildings, an unheated 1,200 sq.ft. shed and a heated 1,050 sq.ft. garage are also used. The garage, which is on a slab floor, has R20 walls and an unknown thickness of insulation in the roof. The concrete slab does not appear to be insulated around its perimeter. The steel overhead doors require weatherstripping. A 115,000 BTU/h forced air oil furnace supplies the heating requirements for this garage. The total energy requirements, as well as some of the construction details, were obtained verbally from the Department of Highways and Transportation.

Airport Division as follows:

kWh/a	16,176
kW (est)	2
Oil	10,592

OPERATING EXPENSE AND REVENUE

Capital Cost: Department of Indian Affairs
Manitoba Hydro

LAC BROCHET

Operating Costs:	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
General Maintenance Labour & Expense						$ 78	$ 17 830	$ 29 082	
Parts						-	22 190	6 172	
Travelling Expense						-	5 841	9 124	
Contract Labour						-	3 557	6 463	
Fuel and Lube Oil						-	47 668	63 863	
Fuel Haulage Administration						750	1 312	3 203	
Administration						-	1 680	278	
Sub-Total						$ 828	$100 078	$118 185	
Overhead						84	2 282	4 134	
Depreciation						-	350	16 919	
Interest						-	19 882	22 316	
Total Operating Costs						$ 912	$122 592	$161 554	
Total Revenue						-	40 700	155 874	
Profit or (Loss)						(912)	($81 892)	$(5 680)	
kWh Consumption						-	129 689	283 936	
Cost Per kWh ¢						-	94.5	56.9	
Return Per kWh ¢						-	31.4	54.9	47.1

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APPENDIX C - INTERMEDIATE LOAD FORECAST DETAILS

Brochet Treaty Housing

Intermediate Load Forecast Details

According to community base data, most study area residents want new and larger appliances. The total connected electrical load and consumption if new and larger appliances are added to each household is:

	Installed Capacity (kw)	Average Consumption (kwh/year)
Hot water heater (40 gal)	3.0	6,500
Stove	6.0	1,200
Clothes dryer	5.0	900
Automatic washer	0.5	60
Freezer	0.5	1,500
Fridge	0.5	1,200
TV, radio, clocks, etc.	0.5	800
Coffee maker	0.5	72
Lights	1.0	250
Sewer & Water Pipe Heat Tracing	0.2	1,000
Total	17.7	13,500

In order to use an electric hot water heater, the existing pressurized water supply system would have to be extended to each house and a gravity drainage sewer system added.

For houses between 850 to 1,250 sq.ft., Manitoba Hydro sizes each house service according to the following loads:

Hot water heater	0.75 kw
Range	6.0 kw
Dryer	1.25 kw
Basic area (includes lights, receptacles and small appliances)	6.0 kw
Total	14.0 kw

According to Manitoba Hydro, a house with a 100 A main breaker would be rated to handle 14 kw load plus an additional 10 kw of electrical heating. A house with a 125 A main breaker would be rated to handle the 14 kw plus 16 kw of electrical heat. The local transformer for a group of 3 houses is sized at 50% of the total connected load of the houses. The community transformation system is sized for between 30 to 50% of the total connected load.

The 30% diversity factor is based upon a community being served by the electrical grid, which in turn, has significant extra capacity.

The 40 - 50% load factor is used for isolated communities that are served with a single diesel generating system. This 40 to 50% covers appliance and space heating requirements.

For these isolated communities, a diversity factor of 30% for appliances and 50% for electrical heating was considered acceptable. This factor could have been 40% and 40% or 50% and 30%. However, the sum of the expected kw requirements for appliances and electric heating for the selected factor approximate peak heating requirements. For example, a 1,000 sq.ft. well insulated house with all of the above appliances and 10 kw of electrical heating would have the following expected peak kw requirement in January:

Appliances	14 kw x 0.30 =	4.2
Heating	10 kw x 0.50 =	5.0
Total		9.2 kw

The internal heat gains from appliances and lights at 4.2 kw contribute about half of the peak kw requirement.

Assuming only half of the 50 houses add new appliances by 1988 and the 20 new homes expected have new appliances installed, the expected electrical requirement by 1988 is 214 kw (25x4.2+20x4.2+25)

including the 25 houses that have not converted. The electrical consumption at 13.5 mwh (45x13.5+ 216/2) where 216/2 is the present consumption of the 25 houses that do not convert by 1988. By 1993 all existing houses are assumed to convert, and by 2008 the expected electrical requirements would be 672 kw and 2,160 mwh.

Other Buildings:

Assuming the Band Office, Pool Hall, Community Hall and Post Office add some applicances (drink machines, hot water tank in Band Office, etc.), the expected electrical requirement will increase to about 10 kW and 10 mWh. Assuming that by 1998 a new 6,000 sq.ft. Community Complex is constructed to house the Band Office, Pool Hall, Community Hall and Post Office, it will require a forced air furnace(s) with a fan motor(s), lights and other appliances such as TV's, drink machines, etc. The total expected requirement will increase to 15 kW and 20 mWh.

Other Facilities:

Pump House - The present pump house, according to the well pump flow rates on the original drawings can each deliver 75 GPM (only one is used at a time). If the 75 gal/person/day rule of thumb is used to size a proper pumped water system, the 1,600 person water demand in Brochet in year 2008 will be about 83 GPM, which is slightly greater than the installed capacity. There is a concern as to whether one or both of the pumps operating together could meet peak water demand by year 2008. An increase in the size of the system was not assumed since any additional power requirement is very small compared to the entire community needs.

Water Distribution System - If the pressurized water system is extended to each house, approximately 50 ft. of electrical heat tracing is required to prevent freezing of the 3/4" water pipe connections. This load has been incorporated into the housing electrical requirement for both Treaty and Metis houses.

Sewage System - In order to dispose of waste water from showers, baths and sanitary waste, a proper sewage system is required. Assuming two five horsepower pumps (one standby) are sufficient for a sewage lift station, and that the sewer lines from the main to the house are electrically heat traced to prevent freezing (this electrical requirement is included in the housing requirements), the electrical requirement would approach 5 kW for the pump and 7 kW for the heat tracing on main sewer lines for a total annual consumption of 80 mWh.

Brochet Metis Housing - According to the community base data, most of the people want new and larger appliances. Assuming the Metis use similar appliances to the Treaty Indians and that only half of the 41 households add these appliances by 1998 along with 15 new houses, the electrical requirement will be 189 kW and 756 mWh. By 1993, all remaining Metis houses are assumed to have converted and by 2008, the expected electrical requirements would be 446 kW and 1,500 mWh.

Brochet Non-Native:

Fathers and Sisters House and Church - Assuming similar appliances, additional lighting and a small hot water tank for a wash basin are added to these houses and the Church, the expected electrical requirement would be about 10 kW and 20 mWh.

School and Teacherages - It is assumed that existing propane and oil domestic hot water tanks and propane stoves are replaced with electric hot water tanks and electric stoves for the School and Teacherages. Few if any additionai appliances are acquired for the Teacherages since they are not presently on a capacity limitation. The expected increased electrical requirement would be 30 kW and 80 mWh.

Due to the increasing population, the School and Teacherages are expected to double in size at some point over the next 25 years. Assuming this happens in 1998, the electrical requirement for that year would also double.

Nursing Station - Since the Station is not subject to capacity limitation, the only appliance to be converted would be the oil hot water heater. A new 60 gal. electric hot water heater will add about 2 kW and 7 mWh to the Station's expected electrical requirements.

Due to the increasing population, the Station is expected to double in size by 1998. The electrical requirements are also assumed to double at this time.

Hudson Bay Store - Since the Store and Residences are not subject to capacity limitations and since the Store already has an electric hot water tank, no change in the present electrical requirement is expected. However, if the Store size is increased by 3,000 sq.ft by 1998, the requirement would increase proportionally by about 7 kW and 42 mWh.

RCMP Trailer - Since the RCMP Trailer is on a capacity limitation, the only appliances to be converted would be the propane stove and hot water heater. The expected electrical requirement for this single man operation would be aboout 4 kW and 10 mWh.

MTS Building - No change in electrical demand was assumed for this unmanned building.

Airport Terminal and New Warehouse - If a 5,000 sq.ft. heated and lighted warehouse is required by 1998 to store goods, expected electrical requirements would approach 5 kW and 36 mWh. If the Airport Terminal doubles in size by 1998, its electrical energy requirements will also double.

Elderly Care Home - Assuming a 20 bed, 9,000 sq.ft. Elderly Care Home is added by 1998, the expected electrical requirement would be about 20 kW and 120 mWh. This includes 4.5 kW of domestic hot water heating, 3 kW for cooking, 10 kW for lights, 1 kW for freezers, and 1 kW for furnace motors.

Lac Brochet - Treaty:

Housing - According to the community base data most of the people want new and larger appliances. The expected electrical requirement if these new appliances and additional lights are added to each household was estimated to be 30% of 14 kW or 4.2 kW for the Brochet houses and is assumed to be similar for Lac Brochet houses.

Assuming 30 of the Treaty houses add these appliances by 1988 along with 25 new houses, the expected electrical requirement will be 214 kW and 715 mWh. By 1993 all remaining houses are assumed to have converted and by 2008 the expected electrical requirements would be 672 kW and 2,160 mWh.

Other Buildings - Assuming the Band Office, Pool Hall, Community Hall and Post Office add some appliances (drink machines, hot water tank in Band Offices, etc.), the expected electrical requirement will be about 10 kW and 13 mWh and remain constant until year 1998. By 1998 a new 4,000 sq.ft.

Community Complex is assumed to house the Band Office, Pool Hall and Post Office. The Complex is assumed to use forced air furnace-(s) with fan motor(s), lights and other appliances such as TV's, drink machines, etc., for an expected electrical requirement of about 10 kW and 13 mWh.

The Father's House is seldom used and the Church used in the evenings only with negligible increase in electric appliances. The expected electrical requirement would remain at about 1 kW and 2 mWh.

Other Facilities:

Pump House - A new heated and lighted pump house sized to handle 75 gpm would have an expected electrical requirement of about 9 kW and 30 mWh. This size of pump house should be adequate for the expected population increase through to year 2008.

Water Distribution Size - If a pressurized water system is extended to each house, electric heat tracing for about 50 ft. of the 3/4" connection will be required. This load has been included in the housing electrical requirements.

Sewage System - In order to dispose of waste water from showers, baths and sanitary waste, a proper sewage system is required. Assuming two five horsepower pumps (one standby) are sufficient for a sewage lift station and that the sewer lines from the main to the house have to be electrically heat traced to prevent freezing (included in housing electrical requirement), the expected electrical requirements would be about 5 kW for the pump and about 7 kW for the heat tracing on main sewer lines for a total annual consumption of 40 mWh.

School and Teacherages - Assuming that existing propane domestic hot water tanks and stoves in the Teacherages are replaced with electric appliances, new electric hot water heaters are added for each 2 classroom building and no appliances are acquired since these buildings are not presently on a capacity limitation, the increased expected electrical requirement would be 15 kW and 40 mWh.

As the educational facility is presently undersized, it is expected that the School and Teacherages will double in size by 1988 and increase a further 50% by 1998. The electrical requirements are also expected to double by 1988 and increase by 50% by 1998.

Lac Brochet - Non-Native:

Nursing Station - Since the Station is not subject to capacity limitations, the only appliances to be converted would be the propane hot water heater, dryer and stove. The increase in expected electrical requirement would be about 5 kW and 11 mWh.

Due to the increasing population, it is expected that the Station and its expected electrical requirement will double in size by 1998.

General Store - Since the Store is not subject to capacity limitations, no change in the present demand is expected. However, if the facility is increased by 1,000 sq.ft. by 1998 and more appliances and lighting added, then the increased expected electrical requirement demand would approach 3 kW and 8 mWh.

General Store - Since the Store is not subject to capacity limitations, no change in the present demand is expected. However, if the facility is increased by 1,000 sq.ft. by 1998 and more appliances and lighting added, then the increased expected electrical requirement demand would approach 3 kW and 8 mWh.

RCMP Trailer - The RCMP Trailer is presently on an electrical capacity limitation. Assuming that the propane stove and hot water heater will be replaced with electrics and additional electrical appliances used, the expected electrical requirement would be about 4 kW and 10 mWh. This electrical requirement assumes that the station would be manned in the future.

MTS Building - No change in electrical demand was assumed for this unmanned building.

Airport Terminal and New Warehouse - If a 4,000 sq.ft. heated and lighted warehouse is required by 1998 to store goods, the expected electrical requirements would be about 4 kW and 24 mWh. Assuming the Airport doubles in size by 1998, the electrical requirement will also double by 1998.

Elderly Care Home - Assuming a 15 bed, 5,000 sq.ft. Elderly Care Home is added by 1998, the expected electrical requirement would approach 12 kW and 70 mWh. This includes domestic hot water heating, stoves, lights, freezers, and furnace motor(s).

APPENDIX D - HIGH LOAD FORECAST DETAILS

Brochet - Treaty:

Housing - To estimate the present housing stock electrical requirements for space heating, a heat loss calculation was performed for houses with R12 and R20 throughout assuming an estimated air change rate (AC/h) of 1 per hour.

Calculations were performed for two sizes of house (800 and 900 sq. ft.) as well as for new house construction (Energy Efficient - EE) with R20 walls and floor, R40 ceiling, triple glazed windows and a 3/4 AC/h. Peak heating requirements are as follows:

Thermal Resistance	AC/h	Existing Housing 800 sq.ft.	Existing Housing 900 sq.ft.	New Housing 1000 sq.ft.
R12 Throughout	1	12 kW	13 kW	
R20 Throughout	1	10 kW	11 kW	
R20 Walls & Floor R40 Ceiling	3/4	7.5 kW	8 kW	9 kW

Of the 50 existing Treaty houses, 25 will convert, and, along with the 20 new energy efficient houses by 1988, will have the following expected electrical space heating requirement:

kW	
25 existing houses at 900 sq.ft. and R20 throughout (24) (11 kW) (0.50) =	138 kW
20 new energy efficient homes at 1,000 sq.ft. and R40 ceiling, R20 walls and floor (20) (9kW) (0.50) =	90 kW
Total	228 kW

This factor, added to the requirements for modern household appliances derived in Table 5-8 yields a total expected kW of 442 (228 + 214) by 1988.

mWh

Using the Manitoba Hydro formula for estimating annual electrical consumption:

$$Q + \frac{\text{(Peak kW Requirement)(Degree Days) C}}{\text{Winter Design Temperature Difference}}$$

- Where the Degree Days for Brochet are 8,462.
- The C factor that accounts for internal heat gains from appliances, lights, solar, people, is 14 for residential.
- The winter design temperature difference is 61^0C.

$$Q_{\text{existing houses}} = \frac{(11)(8,462)(14)}{61} = 21,400 \text{ kWh}$$

With a 20% reduction due to wood heating 17,000 kWh.

$$Q_{\text{new houses}} = \frac{(9)(8,462)(14)}{61} = 17,500 \text{ kWh}$$

With a 20% reduction due to wood heating 14,000 kWh.

The total for both new and existing houses (17,000)(25) + (14,000)(20) = 705,000 kWh. When added to the requirements for modern household appliances identified in Table 5-8 a total expected mWh requirement of 1,420 mWh (705 + 715) by 1988 is determined.

Other Buildings - Based upon investigation, the expected space heating electrical requirement for the Band Office, Pool Hall, Community Hall and Post Office is about 25 kW without weatherstripping and sealing and about 20 kW with sealing improvements. Assuming that a new 6,000 sq.ft. Community Complex is constructed by 1998, to EE standards, the expected space heating electrical requirement is about 25 kW and 50 mWh.

Other Facilities:

Pump House and Sewage House - The Pump House oil furnace is rated for 93,000 BTU/h. At a combustion efficiency of 75% the equivalent electric heating required would be 20 kW. If the door is weather-stripped and cracks caulked, this could probably be reduced to about 18 kW. The expected requirement would then be 9 kW and 17 mWh.

A new sewage lift station would have an expected requirement of 3 kW and 5 mWh if constructed to new EE standards. The total for both facilities would then be 12 kW and 22 mWh.

Brochet - Metis:

According to the Housing Survey, about 80% of the houses have R12 throughout and 20% have R20 throughout. 40% of the houses are about 960 sq.ft. and the remainder are less than 860 sq.ft. Using the previous calculations for Treaty houses, 20 of the 41 Metis houses are assumed to convert, and, along with the new 15 energy efficient houses constructed by 1988, will have an expected electrical space heating requirement of 233 kW and 720 mWh. This factor is added to the requirements for modern household appliances illustrated in Table 5-8 to yield a total expected requirement of 422 kW and 1,460 mWh.

Brochet - Non-Treaty:

Fathers House, Sisters House and Church

Based on the furnace size of the houses and age and construction of the Church, the expected space heating demand is about 70 kw. If the Fathers House an Church basement are insulated iwth R20 insulation and all 3 buildings are insulated with R20 insulation and all 3

buildings are weatherstripped and sealed, this could be reduced to about 50 kw. The expected electrical space heating requirement would be 25 kw and 48 mwh.

School and Teacherages

Based on 1 140,000 BTU/h input rating for each of the 13 school furnaces and a 70% combustion efficiency of the older furnaces, the space heating demand calculated for the school approaches 375 kw. Due to the operation of the furnaces and the usual tendency to oversize furnaces, the actual demand is closer to 300 kw. During a peak condition, say 5:00 p.m., most of the lights will be off and the school still warm, the expected electrical requirement approaches 150 kw and 500 mwh.

The 13 teacherages comprise a total area of 9,000 sq.ft. and will require about 60 kw and 255 mwh of electrical heating. This is based on the overall thermal resistance of the houses estimated at R12 and 1 air change per hour. This load could be reduced to about 50 kw and 188 mwh if weatherstripping and air sealing were incorporated to reduce airchange to .75 per hour. The total demand for the school and teacherages is 200 kw and 688 mwh and is expected to double by 1998 when an additional 20,000 sq.ft. of educational area is required along with the necessary additional teacherages.

Nursing Station

Based on the two 140,000 BTU/h furnaces and 70% combustion efficiency, the new station will require 57 kw of electrical heating. The old nursing station with its five 94,000 BTU/h rated furnaces will require about 96 kw of electrical heating. The old station is used seldomly and is maintained at a low temperature. Both sets of furnaces in the new and old nursing station are probably at least 20%

oversized. The 500 sq.ft. workshop will require about 6 kw to heat-With weatherstripping and sealing, the total expected electrical space heating requirement is 64 kwh and 250 mwh.

If the station doubles in size by 1998, the demand is also expected to double.

Hudson Bay Store and Houses

Based upon 190,000 BTU/h and 135,000 BTU/h oil furnaces in the store, 70% efficiency, 20% oversizing and 1,200 sq.ft. and 900 sq. ft. residences, the expected demand is 80 kw.

If the store's basement and crawlspace walls were insulated with R20 and both the store and residences weaterstripped and sealed, the total demand would be reduced to about 64 kw. The expected electrical requirement will then be 32 kw and 125 mwh. If the store increases by 3,000 sq.ft. in 1998, the new electrical requirement would be 60 kw and 291 mwh.

RCMP Trailer

Based on the 84,000 BTU/h furnace, the expected electrical requirement is about 4 kw and 10 mwh.

Airport and Garage

Based on a 100,000 BTU/h furnace in the terminal and two 100,000 BTU/h furnaces in the garage, the electrical demand is 50 kw.

If the terminal and garage are weatherstripped/sealed, the total demand would be reduced to about 40 kw and the expected requirement would be 20 kw and 80 mwh. If the terminal size is doubled in 1998, the electrical requirement is also expected to double.

Elderly Care Home

If a 9,000 sq.ft. elderly care home were added to the community in 1998, it would have an expected space heating requirement of 40 kw and 150 mwh.

Community Complex

See "Other Buildings" above.

Warehouse

If a 5,000 sq.ft. warehouse were added at the airport in 1998, it would have an expected space heating requirement of 25 kw and mwh.

Lac Brochet - Treaty:

Housing

According to the community base data there are 45 houses at Lac Brochet. Most of these are newer and smaller than Brochet Treaty houses. About 25% are of a log construction and are being rapidly replaced. Assuming that 30 of the newer houses convert to electric space heating along with the 25 new houses expected, the associated space heating requirement is 272 kw and 860 mwh by 1988. This factor is then added to the expected requirements for new appliances (Table 5-9) to yield the total requirement.

Other Buildings

Based upon investigation, the space heating electrical demand for the band office, pool hall, community hall, is about 45 kw. With weatherstripping and sealing, this could be reduced to about 35 kw. The expected electrical space heating requirement is 18 kw & 62 mwh.

Assuming that by 1998, a new 4,000 sq.ft. community complex is constructed to EE standards, the expected electrical space heating requirement for the complex is about 25 kw and 58 mwh.

Fathers House and Church

The expected electrical space heating requirements for both buildings is 16 kw and 31 mwh.

Other Facilities

Pump House and Sewage House - The new pump house and sewage lift station, if constructed to EE standards, will have an expected requirement of about 10 kw and 33 mwh.

School and Teacherages - Based upon a 115,000 BTU/h rating for each of the 9 school furnaces and a 70% combustion efficiency an furnace oversizing, the space heating demand for the school is calculated to be 170 kw. With weatherstripping and sealing, the maximum space heating demand could be reduced to about 140 kw.

The expected electrical space heating requirements for the school is 70 kw and 230 mwh by 1988.

The teacherages will require about 60 kw of electrical heating, and, if weatherstripped and sealed, this could be reduced to 50 kw. The total expected electrical space heating requirement is 95 kw and 310 mwh. It is anticipated that the education facility and its electrical requirements will double by 1993 and increase by 50% by 2003.

Lac Brochet - Non-Native:

Nursing Station and Workshop

Based upon the two 91,000 BTU/h furnaces, 70% combustion efficiency and 20% oversizing, the station will require 30 kw of electrical heating. The workshop with its 48,000 BTU/h oil space heater will require about 8 kw of electrical heating. With weatherstripping and sealing, the total maximum electrical space heating demand for both buildings will be reduced from 38 kw to about 30 kw. The expected contribution to peak demand resulting from their facility would be 15 kw (based upon a diversity factor of 50%) and 60 mwh. On the basis that the station doubles in size by 1998, the electrical requirement is also expected to double.

General Store

Based upon a 112,000 BTU/h wood/oil furnace in the store, the maximum demand is 30 kw. The expected requirement is 15 kw and 60 mWh. If the store increased by 1,000 sq.ft. in 1998, the new requirement would be 20 kw and 80 mwh.

RCMP Trailer

Based upon a 30' x 12' trailer with R12 throughout, the expected requirement is about 4 kw and 10 mwh.

Airport Terminal and Garage

Based upon a 45,000 BTU/h oil space heater in the terminal and a 112,000 BTU/h furnace in the garage, the maximum electrical demand is 30 kw.

If the terminal and garage are weatherstripped and sealed, the total demand could be reduced to about 26 kw. The expected requirement is 13 kw and 50 mwh. If the terminal size is increased to 1,500 sq.ft. in 1998, the electrical heating requirement anticipated is 32 kw and 100 mwh.

Elderly Care Home

If a 5,000 sq.ft. elderly care home were added to the community in 1998, it would have an expected electrical space heating requirement of 28 kw and 65 mwh.

Community Complex

See "Other Buildings" above.

Warehouse

If a 3,500 sq.ft. warehouse were added at the airport in 1998, it would have an expected electrical space heating requirement of 17 kw and 26 mwh.

E.1 COCHRANE RIVER - HYDROLOGY

E.1.1 General Geography

Wollaston Lake is a large lake in northern Saskatchewan which is perched on the drainage divide between the Arctic Ocean and Hudson Bay. The Fond-du-Lac River flows from the northwest corner of the lake in a generally northwesterly direction into the Slave/Mackenzie system. The Cochrane River flows from the northeast corner of Wollaston Lake, and travels first in a westerly direction into Manitoba and then in a southerly direction before emptying into Reindeer Lake near the community of Brochet. The Cochrane River carries the major proportion of outflow from Wollaston Lake, and the large storage capacity of the lake gives a high degree of regulation to the river flows throughout the year.

E.1.2 River Flow Records

Water Survey of Canada has maintained a hydrometric station on the Cochrane River since 1968, although for the first four years, the records were intermittent. A summary of the published data from this station is given in Table E-1.

In addition to this direct source of information on the river flows, indirect methods have been used to develop supplementary data. An extended period of record for the Cochrane River was developed as follows

- Water Survey of Canada have recorded water levels on Wollaston Lake since 1952 on a nearly continuous basis. Also, intermittent meterings of the Cochrane and Fond-du-Lac Rivers were done by Churchill River Power Company and Water Survey of Canada over a period of years from 1949 to 1973. A rating curve of the Cochrane River flows at the outlet of Wollaston Lake (Bigstone Rapids) has been developed and used with the known record of lake levels to compute mean monthly flows at that location.

- the "overlapping" period of record of the Cochrane River flows at Wollaston Lake and near Brochet (1968 to 1982) was used to develop a correlation in monthly flows between the two locations.

- the correlation was then used to estimate the Cochrane River flows near Brochet for the period 1952 to 1968, as well as for the intermittent months after 1968 when recorded flows do not exist. This extended record of mean monthly flows is given in Table E-2, and shows a long term average flow of 149 m^3/s.

Hydroelectric development of the Cochrane River to serve Brochet and Lac Brochet would be at a site between Lac Brochet and Reindeer Lake. River flows along this reach increase in the downstream direction as a result of tributary streams. To bracket the range of flows involved, records for Lac Brochet were estimated by the following proration.

$$Q_{LAC\ BROCHET} = Q_{BROCHET} - Q_{WOLLASTON} * \frac{A_{LAC\ BROCHET}}{A_{BROCHET}} + Q_{WOLLASTON}$$

where

$Q_{LAC\ BROCHET}$ = mean monthly flow of the Cochrane River at the outlet of Lac Brochet (m^3/s)

$Q_{BROCHET}$ = mean monthly flow of the Cochrane River near Brochet (m^3/s, from Table 3)

$A_{LAC\ BROCHET}$ = drainage area between the outlet of Wollaston Lake and the outlet of Lac Brochet (6,250 km^2)

$A_{BROCHET}$ = drainage area between the outlet of Wollaston Lake and the metering gauge near Brochet (8,900 km^2)

$Q_{WOLLASTON}$ = mean monthly flow of the Cochrane River at the outlet of Wollaston Lake (m^3/s)

TABLE E-2

MEAN MONTHLY FLOWS IN

COCHRANE RIVER NEAR BROCHET

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1952	92	89	85	85	130	148	126	130	122	114	112	110
1953	99	94	86	86	130	147	128	137	132	131	125	120
1954	112	105	97	95	138	176	157	164	152	130	119	114
1955	102	100	92	91	154	202	176	175	151	125	113	106
1956	97	92	88	90	120	134	119	108	88	82	66	66
1957	60	58	53	55	75	115	106	113	93	94	83	80
1958	72	72	69	68	117	158	150	162	150	135	128	122
1959	130	105	100	105	150	203	195	196	199	182	170	156
1960	143	130	109	132	182	246	260	247	230	195	172	148
1961	135	122	112	125	190	237	223	225	205	165	155	140
1962	128	120	105	111	162	216	210	192	170	146	130	123
1963	113	107	99	100	150	190	186	202	210	195	173	152
1964	134	121	111	130	188	206	190	225	235	221	195	166
1965	147	127	114	120	170	200	180	172	155	138	130	123
1966	112	103	93	99	146	186	180	178	160	135	120	113
1967	104	100	89	86	131	183	192	195	176	147	130	120
1968	100	89	78	91	142	172	225E	189	169	200E	150	138
1969	142	112	99	89	122	155E	170	163	150E	135	123	116
1970	114	106	97	85	132	160E	128	212	149	169	166	137
1971	121	112	103	100	155	164E	145	181E	201	219	199	165
1972	143	117	95	97	190	242	254	234	226	211	177	166
1973	147	133	121	110	163	192	199	170	142	134	125	111
1974	104	99	96	96	170	170E	175	184	176	161	142	129
1975	117	109	103	104	178	212	237	220	190	175	154	138
1976	130	126	124	145	187	229	238	187	198	218	199	173
1977	155	144	139	172	252	314	366	336	296	268	236	194
1978	156	131	116	113	209	260	247	272	272	260	226	195
1979	170	141	120	111	161	207	204	168	152	153	140	127
1980	115	107	103	131	157	148	153	209	248	220	184	152
1981	129	122	119	120	178	206	197	164	145	128	109	95
1982	90	86	82	80	171	214	189	160	151	148	131	117
1983*	162	151	154	146	138	182	210	223	261	253	217	165

E - Estimated from partial records

*Preliminary from WSC Regional Office in Thompson

Averages	120	109	100	104	158	193	190	186	180	169	150	134

Overall Average 1952 - 82 Incl. 149 m^3/s

Note: Underlined values determined by correlation with Wollaston outflows.

TABLE E-2

MEAN MONTHLY FLOWS IN

COCHRANE RIVER NEAR BROCHET

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1952	92	89	85	85	130	148	126	130	122	114	112	110
1953	99	94	86	86	130	147	128	137	132	131	125	120
1954	112	105	97	95	138	176	157	164	152	130	119	114
1955	102	100	92	91	154	202	176	175	151	125	113	106
1956	97	92	88	90	120	134	119	108	88	82	66	66
1957	60	58	53	55	75	115	106	113	93	94	83	80
1958	72	72	69	68	117	158	150	162	150	135	128	122
1959	130	105	100	105	150	203	195	196	199	182	170	156
1960	143	130	109	132	182	246	260	247	230	195	172	148
1961	135	122	112	125	190	237	223	225	205	165	155	140
1962	128	120	105	111	162	216	210	192	170	146	130	123
1963	113	107	99	100	150	190	186	202	210	195	173	152
1964	134	121	111	130	188	206	190	225	235	221	195	166
1965	147	127	114	120	170	200	180	172	155	138	130	123
1966	112	103	93	99	146	186	180	178	160	135	120	113
1967	104	100	89	86	131	183	192	195	176	147	130	120
1968	100	89	78	91	142	172	225E	189	169	200E	150	138
1969	142	112	99	89	122	155E	170	163	150E	135	123	116
1970	114	106	97	85	132	160E	128	212	149	169	166	137
1971	121	112	103	100	155	164E	145	181E	201	219	199	165
1972	143	117	95	97	190	242	254	234	226	211	177	166
1973	147	133	121	110	163	192	199	170	142	134	125	111
1974	104	99	96	96	170	170E	175	184	176	161	142	129
1975	117	109	103	104	178	212	237	220	190	175	154	138
1976	130	126	124	145	187	229	238	187	198	218	199	173
1977	155	144	139	172	252	314	366	336	296	268	236	194
1978	156	131	116	113	209	260	247	272	272	260	226	195
1979	170	141	120	111	161	207	204	168	152	153	140	127
1980	115	107	103	131	157	148	153	209	248	220	184	152
1981	129	122	119	120	178	206	197	164	145	128	109	95
1982	90	86	82	80	171	214	189	160	151	148	131	117
1983*	162	151	154	146	138	182	210	223	261	253	217	165
Averages	120	109	100	104	158	193	190	186	180	169	150	134

E - Estimated from partial records

*Preliminary from WSC Regional Office in Thompson

Overall Average 1952 - 82 Incl. 149 m^3/s

Note: Underlined values determined by correlation with Wollaston outflows.

The derived flow record for the Lac Brochet location shows a long-term average flow of 132 m^3/s, or about 90% of the flow near Brochet.

E.1.3 Flow Variation

The flow records for the Cochrane River have been analyzed on a monthly basis to determine flow duration curves for use in determining hydro-electric energy potential. Overall annual duration curves have also been estimated from this data.

As described in Section E.1.2 above, monitoring of water levels on Wollaston Lake began in 1952, and there are no published records prior to that time. Extension of the record back to 1929 to supplement the more recent records was done by correlation with computed inflows to Reindeer Lake from Churchill River Power Company records.

This extended record demonstrates that

- the low flow period of 1957 was not only the lowest since 1952 but also likely the lowest since 1929, and would be a good indicator of the firm flow at the hydro sites. A value of 55 m^3/s has been estimated for this firm flow in late winter in both the Brochet and Lac Brochet areas.

- the high flow period of 1977 was not only the highest since 1952 but also likely the highest since 1929.

E.1.4 Frequency Analysis of Flood Flows

A frequency analysis of the peak annual flood flows from 1952 to 1982 was done for both locations on the Cochrane River. The peak flood flow used in each year was based on

- either the recorded peak daily value from Water Survey of Canada

- or, in the years where no peak daily value was available, it was estimated as the peak monthly mean, increased by 10 percent to

recognize the variation in flow during the month. The 10 percent represents a reasonable upper limit of peak daily flow compared to the monthly mean flow in the historical record of 1968 to 1982.

- peak flows at Lac Brochet were based on the flows at Brochet, with a proration according to drainage area as described in Section E.1.2 above.

The frequency curves were plotted using the Hazen method on log- normal paper, with a straight line fit by eye. Floods of various probabilities were estimated using these curves, and are summarized below.

Annual Probability of Exceedence	Peak Flows at Brochet	Peak Flows Lac Brochet
50 % (1- in 2-yr)	220	180
20 % (1- in 5-yr)	260	220
10 % (1- in 10-yr)	290	240
5 % (1- in 20-yr)	310	260
1 % (1- in 100-yr)	360	300
0.1 % (1- in 1 000-yr)	430	360
0.01% (1- in 10 000-yr)	480	400

E.1.5 Reindeer Lake

Reindeer Lake is a natural water body whose level was artificially raised by about 10 ft in 1937 by the construction of the Whitesand Dam at the south end of the lake. The reservoir has been used to maximize the energy output from the Island Falls hydro plant located downstream on the Churchill River. That plant and the Whitesand Dam were recently acquired by Saskatchewan Power Corporation. The lake will likely be regulated in the coming years in much the same way that it was since 1937.

The range of lake levels is presently licensed to be within el 334.06 to 336.65 m. In most normal years in the past, the lake level has been held near el 336 m, but in dry years such as 1969/70 and 1982/83, the lake levels have reached the lower 1 m of storage. The lake level has never exceeded the upper limit of el 336.65 m except temporarily in local areas due to transient seiches on the lake.

E.2 SITE IDENTIFICATION

The Cochrane River drops some 25 m from its level at Lac Brochet to its outlet at Reindeer Lake. A profile of the river is shown on Figure E-1. Potential for hydroelectric development of some of this head exists in three main areas.

- in the lower 15 km of the river
- in the upper 25 km near the outlet of Lac Brochet
- at a diversion route through Kakanukamak and Engen Lakes to Birch Bay.

Locations of the most promising sites were identified on topographic maps early in the study. These locations are shown on Figure E-2.

E.3 SITE RECONNAISSANCE

E.3.1 Objectives

On October 11 and 12, 1983, a group of Acres' staff visited Brochet and the Cochrane River to inspect potential low-head hydroelectric sites on the Cochrane River between Lac Brochet and Reindeer Lake which had been identified in previous office study. The goals of the field trip were

- conduct a flyover of the river and potential sites
- conduct a walkover survey of the more promising sites
- review environmental concerns

E.3.2 Trip Outline

On October 11, 1983, the lower Cochrane River was viewed from the air and landings made at Axes L-3 and L-4 for walkover inspections. Axes

L-1, L-2 and L-5 appeared to have very low potential and were not inspected in detail. A preliminary survey of head drop at Axes L-3 and L-4 was made by hand-level and rod. A transmission line/access route from these sites to Brochet was flown and the group spent the night at Brochet.

On October 12, 1983, the entire reach of the Cochrane River was flown and the upper sites (Axes U-1 to U-5) visited. Axes U-3 and U-5 were selected as the most promising from the air and landings were made at both axes to allow a brief walkover inspection and survey measurement of head drop at these sites. The diversion route through Engen Lake to Perch Bay was then flown but the limited remaining hours of daylight prevented a walkover inspection.

The use of the helicopter during the visit was restricted several times due to snow squalls and fog, and site inspections were necessarily brief.

E.3.3 Engineering Observations

The estimated natural head drop at each of the axes is summarized as follows

Axis	Head Drop	Comment
L-1	negligible	estimated from air
L-2	negligible	estimated from air
L-3	2.8 m	surveyed
L-4	1.3 m	surveyed
L-5	1 m	estimated from air
U-1	negligible	estimated from air
U-2	0.5 m	estimated from air
U-3	1.0 m	estimated from air
U-4	1 m	estimated from air
U-5	2 m	surveyed
U-5A	7 m	estimated from topographic maps
DIVERSION	11 m	estimated from topographic maps

Detailed observations from the reconnaissance are summarized below.

Lower Cochrane River

Axis L-3

The head drop across the rapids was approximately 2.8 m, with the flow approximately 240 m^3/s as obtained from the Water Survey of Canada gauge a few kilometres upstream. The river is approximately 90 m wide at the rapids.

The west bank is granodiorite with thin soil cover as shown in Figure E-3. The east bank consists of granodiorite capped by a fluvial terrace. This terrace could create a problem of seepage if a significant head is impounded at this site. Also, a low gully which bypasses the rapids to the east would require a dyke to maintain an impounded forebay.

Axis L-4

Observations at Axis L-4 are shown on Figure E-4. The river flows through a narrow channel with granodiorite exposed for 3 to 4 m above river level on both banks with a capping of granular terrace material above bedrock on the east bank. The quality of the rock for structure foundation purposes is considered excellent.

Construction Materials

Both Axes L-3 and L-4 have massive to poorly jointed granodiorite outcropping along the west bank of the Cochrane River with little or no soil cover. An extensive esker exists 1 km west of Axis L-3 and contains medium to coarse sand with some fine to medium gravel. No glacial till outcrops were noted in the immediate vicinity of the Axes L-3 and L-4 but judging from regional geology, till is probably available within 4 km from drumlinoid ridges or other sources. Till deposits can be expected to contain a high proportion of cobbles and boulders.

Upper Cochrane Axes

The potential axes on the upper Cochrane River near Lac Brochet were inspected from the air with landings made at Axes U-3 and U-5.

Axis U-3

Chipewyan Falls has a natural head drop of approximately 1 m. The width of the river at this location was estimated to be 110 m. Both banks are of massive granodiorite with little or no soil covering.

Axis U-5

At this location, the Cochrane River loops around a neck of land (120 m wide at its narrowest point) with approximately a 2 m head existing across the loop. Rock was not exposed at the surface but depth to bedrock is likely less than 2 m, with a covering of boulders. Rock outcrops exist on the rising ground 200 to 400 m to the south of this location.

Construction Materials

Axes U-2 to U-5 have ample sources of rockfill at a short haul distance along the right bank of the Cochrane River. Time did not permit specific survey for construction materials but both till and sand/gravel are considered to be available along the east bank within a 4 km haul distance.

Diversion Route Through Engen Lake

Time did not permit a landing and walkover of the various areas along the diversion route except at Kamacheechawasik Rapids. At that location, the river drops approximately 1 m through an 80 m wide set of rapids. Rock was not visible on the surface on either abuttment although it appears to form the riverbed. The east bank slopes gently up from the river with a granular terrace of indeterminate, but probably shallow, depth.

In the areas where channel excavation would be required, between the Cochrane River and Engen Lake, no rock outcrops were apparent and it is likely that the excavation would be in overburden.

E.3.4 Geotechnical Considerations

The Cochrane River area is in the northern portion of the discontinuous permafrost zone. Mean air temperature is 22 - 23°F and low-lying areas frequently exhibit evidence of significant ground ice contents. This factor would be of significance relative to layout of

- dykes and embankments away from the Cochrane River. Use of self-healing, granular fill would be necessary.

- transmission lines and access roads. Areas of low-lying muskeg should be avoided to the maximum extent possible and access considerations would necessitate winter construction.

Rock outcrops examined showed sound, massive to jointed granite or granodiorite. Significant foundation problems are unlikely for a development of the scale considered. Rock forms the riverbed for all axes examined closely, and depth of alluvium is considered to range from nil to minor.

Granular terraces and eskers along the Cochrane River should supply granular borrow and aggregate at haul distances of 6 km or less for all sites visited.

Impervious till borrow is available in drumlinoid ridges but haul distance may be greater than for granular material and the till can be expected to have a high boulder/cobble content.

E.4 SITE COMPARISON AND SELECTION

E.4.1 Load Scenarios

The physical arrangement and cost of a hydroelectric plant is strongly influenced by the maximum electrical load which it must serve. In the case of Brochet and Lac Brochet, this electrical load is uncertain and will depend on the communities' desires and needs in coming years. To demonstrate this variability in the cost of hydroelectric energy, three scenarios of electrical load were considered in the initial screening of potential sites

- replacement of the present diesel generators with hydroelectric generators, but maintaining the 15 amp restriction on households in the communities; the peak load considered in this case was 300 kW for the combined communities of Brochet and Lac Brochet.

- replacement of the present diesel generators with hydroelectric generators, and permitting 100 amp services to the communities, but not permitting electric heating; the peak load considered in this case was 1,500 kW.

- replacement of the present diesel generators with hydroelectric generators, with unrestricted usage of electricity, including heating electrically; the peak load considered in this case was 4,500 kW.

These scenarios were chosen from the preliminary results of the load projection. Although they were subsequently refined, the figures presented above were considered adequate for the initial screening of site alternatives.

E.4.2 Firm Hydro Capability

Hydroelectric energy is a product of a volume of water falling through some distance. If the volume of water available is restricted for some reason, then it follows that the potential hydroelectric energy is also restricted. It is therefore important in designing a hydroelectric station to estimate the river flow as it would be under very dry conditions. In the case of the Cochrane River, as described in Section E.1.3 above, this "firm" river flow is estimated to be 55 m^3/s, which occurred for several months in the winter of 1956 - 57. This is estimated to be the lowest flow in the period from 1929 to the present.

E.4.3 Number of Generating Units

For the plant sizes considered in this study, the most economic arrangement would be attained with one turbine/generator unit. However, during a plant outage for routine maintenance or due to equipment malfunctions, there would be no electricity available to the communities. Since this would be unacceptable, particularly if electric heating is considered, a two-unit plant was assumed in the preliminary layouts and costing. Consideration would have to be given to maintaining the existing diesel generators as emergency standby capacity.

E.4.4 Type of Generating Units

For the Cochrane River, the heads, river flows and required generating capacity are such that the most economical arrangement of the powerhouse would be with tubular units. These units have the advantage of requiring little excavation and a minimum volume of concrete in the structure which contains them. They are also available from standardized designs so that the cost of design is minimized, and more reliable, predictable installation is assured.

E.4.5 Site Selection

300 kW Capacity

Economy for a relatively low capacity installation requires the use of natural falls or rapids to greatest advantage without requiring expensive impounding structures or spillways to pass flood flows. The best opportunity for such a development exists at the falls near the mouth of the Cochrane River (Axis L-3 on Figure E-2). The arrangement envisaged for this development includes an excavated approach channel in the west river bank with a powerhouse at its downstream end. Rock excavated from the channel would be used to construct a timber/rockfill weir which would extend across the 90 m wide rapids. The purpose of the weir would be to increase the upstream water level and to assure a minimum head differential of about 5 m even during severe drought periods. Some placement of rock would be required on the east riverbank opposite the groin to protect against high velocities which would occur during high flow periods. Under normal conditions, the water level upstream of the weir would be increased by approximately 2.5 m above the level which now exist under natural conditions.

While project layouts were attempted at other locations, both on the lower and upper reaches of the Cochrane River, all involved greater costs than Axis L-3. The layout and cost of this scheme were then refined as described in Section 7 - in the main report.

1,500 kW Capacity

Again, the natural fall at Axis L-3 lends itself to the development of the least cost arrangement on the river between Brochet and Lac Brochet. The layout envisaged would have an approach channel excavated in the west river bank with an intake/powerhouse

located at its downstream end, as described above for the 300 kW scheme. An uncontrolled weir across the river and about 2 m high would be constructed at the brink of the rapids and would increase the upstream water level by approximately 2.5 m over natural conditions. A minimum head on the generating units would be approximately 5 m.

Construction of the weir and its tie-in dykes would be done behind a low height earthfill cofferdam built across the river, while the river is diverted through the channel excavated in the west bank. After the spillway is complete, the rock-cut channel would be closed and the intake/powerhouse constructed. Construction of a wing dyke approximately 500 m upstream of the falls on the east river bank would likely be required to seal off a low gully which would carry flow if the river level was increased significantly.

The powerhouse would have two tubular units which each use approximately 20 m^3/s of the river flow. The remainder of the flow would pass over the concrete weir and down the natural rapids.

Layouts at other sites were also investigated for the 1,500 kW alternative. Schemes at Axes L-4, U-3, U-4, U-5-A, U-5-B, and on the diversion route through Engen Lake were devised, but comparative costs indicated that all were more expensive than L-3. Development at Axis L-4 appears to be very close in cost to that at L-3, and may be viewed as an alternative if further study at the 1,500 kW level is undertaken.

The layout and cost of this intermediate scheme at Axis L-3 were then refined as described in Section 7 of the main report.

4,500 kW Capacity

With a firm flow of about 55 m^3/s in the Cochrane River, development of 4,500 kW requires a head of some 10 m. While this is conceivable at Axes L-3 or L-4, it would involve expensive abutment treatment to avoid seepage problems in the granular terrace forming the east bank at both locations. Also, such an impoundment would require a relatively expensive spillway and earthfill dam in the river. Flooding would extend some 50 km upstream. In general such a development appears to be less attractive than other alternatives studied.

Another site for 4,500 kW is at Axis U-1 and U-2, which would involve considerable flooding, but only in the 25 km reach up to Lac Brochet. No significant change in the level of Lac Brochet would be required, however. Both sites require costly rockfill dams, and both sites appear to be considerably more expensive than the diversion route through Engen Lake.

The diversion route involves several components, which at the time of the site screening process, were envisaged as

- a rockfill groin at Kamacheechawasik Rapids, located about 48 km upstream of Reindeer Lake. This would increase the water level by 1 to 2 m upstream so that a portion of the river flow could be diverted through Kakanukamak Lake to Engen Lake.

- a short channel between the Cochrane river and Kakanukamak Lake would be required.

- a channel upstream of Engen Lake would be required.

- some channel improvements at the outlet of Engen Lake and downstream of Kakanukamak Lake would be required.

- some channel improvements at the outlet of Engen Lake and downstream of Kakanukamak Lake would be required.

- rockfill dam with a glacial till seal would be constructed on an arm of Birch Bay (Reindeer Lake), and would impound approximately 11 m of head.

- a concrete intake structure would be built on the north shore to tie into the dam. Flow would be carried down two short 2.5 m diameter penstocks to a two unit powerhouse with a capacity of 4,500 kW.

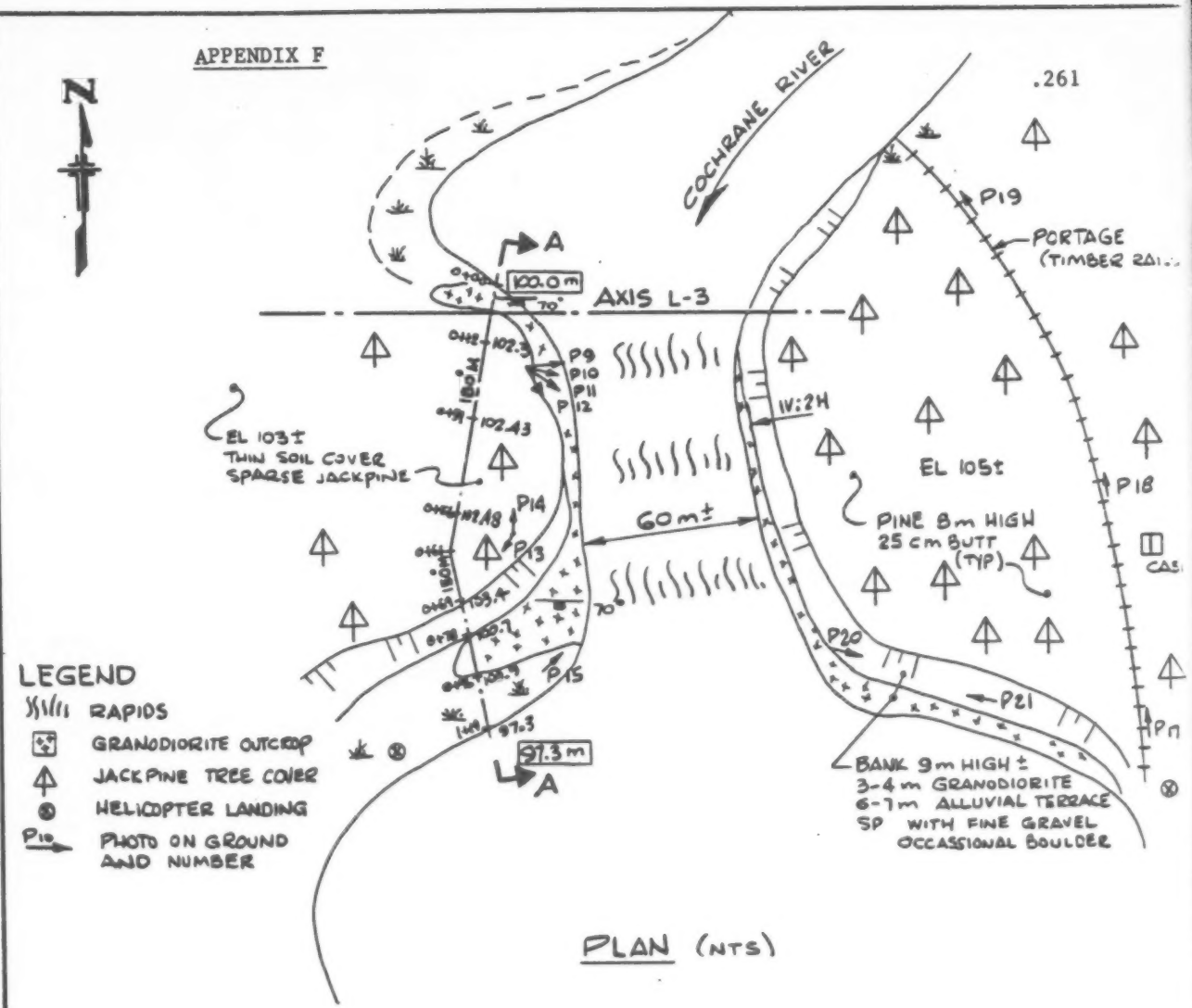
- wing dykes at the southwest corner of Kakanukamak Lake would also be required to avoid spillage out of the catchment area through Muskeko Lake.

- similarly, short, low wing dykes would be required near the outlet of Engen Lake.

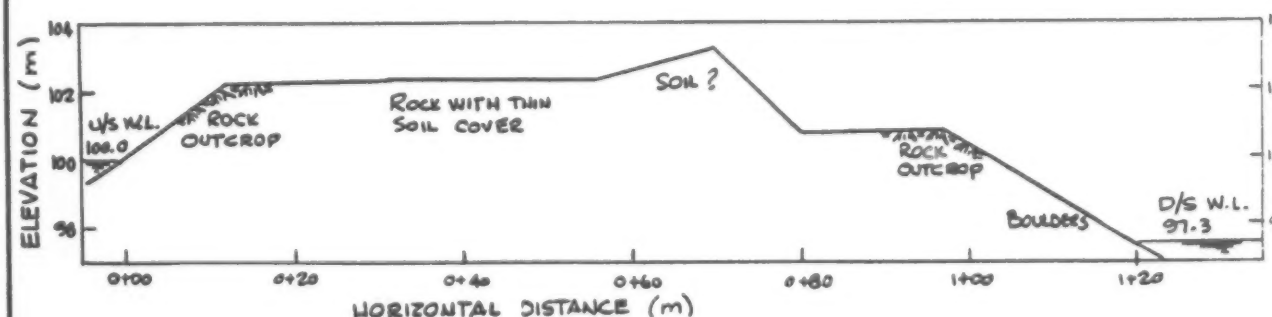
- the level of Engen Lake would be increased by approximately 1 m.

One attractive aspect of the diversion scheme is the access to the powerhouse location by water or winter road on Reindeer Lake. While access to the channel improvements and dykes along the route is difficult, it can be done reasonably cheaply by winter road.

Further refinements to the diversion scheme were made in the subsequent stages of the study to arrive at the arrangement described in Section 7 of the main report.

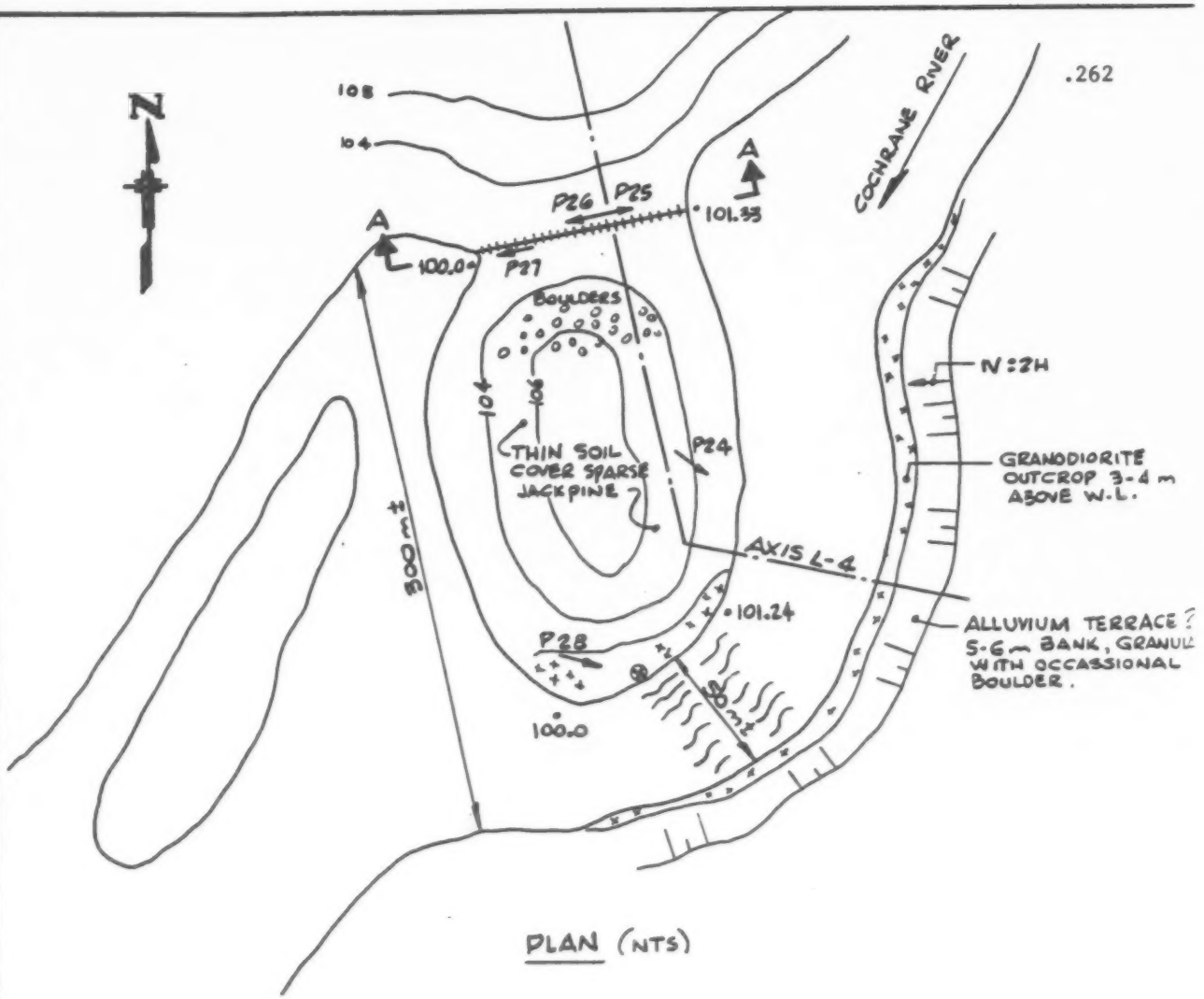


PLAN (NTS)



SECTION A-A

COCHRANE RIVER	
SITE RECONNAISSANCE OCTOBER 11-12, 1983 OBSERVATIONS AXIS L-3	
OCTOBER 17, 1983	FIGURE: E-3



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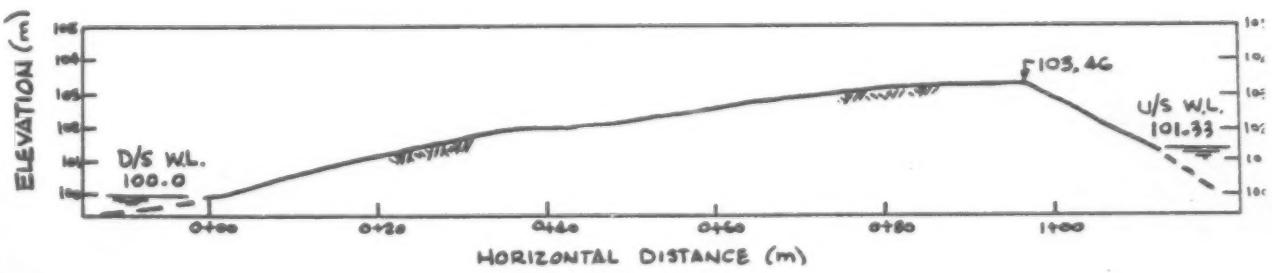

PROFILE A-A

NOTES

1. CONTOURS ARE ESTIMATED
2. PROFILE WITH HANDLEVEL AND PACED DISTANCE

LEGEND

- ⊛ HELICOPTER LANDING
- P27 PHOTO ON GROUND AND NUMBER
- TIMBER BOAT PORTAGE
- RAPIDS
- • ELEVATION (m)

COCHRANE RIVER

SITE RECONNAISSANCE
OCTOBER 11, 1983
OBSERVATIONS
AXIS L-4

OCTOBER 17, 1983 | FIGURE: E-4